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Status of the Northern Leopard Frog (*Rana pipiens*) in Alberta:

Update 2003

Alberta Wildlife Status Report No. 9 (Update 2003)

Alberta Conservation Association

Alberta
SUSTAINABLE RESOURCE DEVELOPMENT

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Status of the Northern Leopard Frog (*Rana pipiens*) in Alberta:

Update 2003

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Alberta Sustainable Resource Development (SRD)
Alberta Conservation Association (ACA)

Update prepared by:
Kris Kendell

Much of the original work contained in the report was prepared by Greg Wagner in 1997.

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PREFACE

Every five years, the Fish and Wildlife Division of Alberta Sustainable Resource Development reviews the status of wildlife species in Alberta. These overviews, which have been conducted in 1991, 1996 and 2000, assign individual species "ranks" that reflect the perceived level of risk to populations that occur in the province. Such designations are determined from extensive consultations with professional and amateur biologists, and from a variety of readily available sources of population data. A primary objective of these reviews is to identify species that may be considered for more detailed status determinations.

The Alberta Wildlife Status Report Series is an extension of the general statusing exercises (1996 *Status of Alberta Wildlife, The General Status of Alberta Wild Species* 2000), and provides comprehensive current summaries of the biological status of selected wildlife species in Alberta. Priority is given to species that are potentially at risk in the province ("At Risk," "May Be At Risk"), that are of uncertain status ("Undetermined"), or those considered to be at risk at a national level by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Reports in this series are published and distributed by the Alberta Conservation Association and the Fish and Wildlife Division of Alberta Sustainable Resource Development. They are intended to provide detailed and up-to-date information which will be useful to resource professionals for managing populations of species and their habitats in the province. The reports are also designed to provide current information which will assist the Alberta Endangered Species Conservation Committee to identify species that may be formally designated as "Endangered" or "Threatened" under Alberta's *Wildlife Act*. To achieve these goals, the reports have been authored and/or reviewed by individuals with unique local expertise in the biology and management of each species.

EXECUTIVE SUMMARY

The northern leopard frog (*Rana pipiens*) has been considered to be an "At Risk" species in Alberta since 1991. In January 1997 it was designated as Threatened under Alberta's *Wildlife Act*.

The species was formerly widely distributed and locally abundant in the Grassland, Foothills and Parkland Natural Regions in the southern half of the province, but abrupt and dramatic population declines were noted in the late 1970s and early 1980s. Populations have remained at a low level since that time. The species now appears to be extirpated over most of western and central Alberta. In southern Alberta, populations are absent or greatly reduced. Since 1990, the northern leopard frog has been reported at 54 sites in the province, although recent evidence of breeding has only been documented at 30 sites. Only 10 sites in southeastern Alberta are considered to support major breeding populations, eight of which showed evidence of successful breeding in 2000-2001. Three sites were identified in 2000-2001 as supporting a large number of frogs and include locations in the Willow Creek drainage, along the North Saskatchewan River in CFB Suffield, and along the Bow River near Bow City.

The cause(s) of population declines in Alberta is unknown. Although little studied, the decline in Alberta does not appear to be part of a regular cycle. Instead, it appears to be related to a widespread factor affecting the survivorship of the species. The abrupt declines observed in Alberta appear to follow a similar pattern of sudden and massive declines witnessed in the upper midwestern states and the other prairie provinces during the 1970s.

Small population recoveries have been noted in Saskatchewan and Manitoba, providing some hope that recoveries may also occur in Alberta. Re-establishment of populations in formerly occupied areas with suitable habitat may occur as a result of dispersal from the remaining populations in southern Alberta. However, dispersal capability of the northern leopard frog is poorly understood, making it difficult to predict the extent to which recolonization will occur, if at all. Changes in the landscape resulting from human activities, coupled with persistent drought, have significantly reduced the leopard frog's ability to naturally disperse into formerly occupied areas. This may be especially true for central Alberta, which is separated from the remaining populations in southern Alberta by vast stretches of arid land.

In an effort to re-establish populations in historic habitats, the Fish and Wildlife Division and the Alberta Conservation Association initiated a leopard frog reintroduction project in 1999. The project involved the captive rearing of leopard frogs under controlled conditions, from egg stage of development to metamorphosed frog, at the Raven Brood Trout Station near Caroline, Alberta. The project has shown initial signs of success at the first of the three carefully selected release sites.

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The first edition of this report was completed when the Fisheries and Wildlife Management Division was part of Alberta Environmental Protection; the Fish and Wildlife Division is now part of Alberta Sustainable Resource Development.

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INTRODUCTION

Over the last 40 years, northern leopard frog (*Rana pipiens*) populations have declined dramatically over much of the species' range in North America. Abrupt population declines were first noted in Alberta in 1979. Since then, populations appear to have been extirpated over much of western and central Alberta and are absent or greatly reduced in southern Alberta. A remnant population, occurring in the extreme northeastern portion of the province, appears to have persisted through the decline. Unlike in many other parts of its range, the agents responsible for the decline may not have affected leopard frogs in this region because they were sufficiently isolated from other populations or because of minimal human activities. Apart from the population in northeastern Alberta, only a handful of viable breeding populations currently remain in southeastern Alberta. Because of its virtual disappearance from the province, the northern leopard frog has been designated as a Threatened* species under Alberta's *Wildlife Act*.

Since 1990, considerable effort has been expended trying to locate northern leopard frogs in Alberta. Known breeding populations have also been routinely monitored and studies have been carried out on two breeding populations to provide more information on dispersal and the general ecology of the species in the province. A third breeding population located in Cypress Hills Provincial Park has been closely monitored since 1998 as part of the Researching Amphibian Numbers in Alberta (RANA) project (Takats 2001), which is associated with the Alberta Amphibian Monitoring Program (AAMP). These programs are joint ventures between the Alberta Conservation Association and the Fish and Wildlife Division. A leopard frog inventory was initiated on a province-wide scale in 2000 and completed in 2001 to collect information on the current status of the species and determine if any changes in population numbers and distribution have occurred since monitoring began. This information, as well as information from other jurisdictions, is reviewed in this report to provide an update on the status of the northern leopard frog in Alberta.

* See Appendix 1 for definitions of selected status designations.

HABITAT

The northern leopard frog requires a mosaic of habitat types to meet the annual requirements of all life history stages, including breeding, non-breeding and overwintering. Generally, separate sites are used for breeding and overwintering (Souder 2000); however, in some cases breeding and overwintering may occur in the same water body. This is particularly true in spring-fed wetlands. In Alberta, northern leopard frogs are typically associated with clear water that is relatively fresh to moderately saline (Wershler 1992a). Some evidence suggests larvae of *Rana* species develop best under pH conditions of approximately 6.5 (Nace et al. 1996). Research conducted by Vatnick et al. (1999) found that the northern leopard frog is more sensitive to acidic conditions than other frog species, particularly when emerging from hibernation. Other parameters of water quality, however, vary widely between sites (Seburn 1992a).

Breeding occurs in shallow and warm standing water associated with permanent and semi-permanent wetlands, springs, dugouts, borrow pits, lakes, beaverponds, and the backwaters and oxbows of rivers (Cook 1966, 1984, Cottonwood Consultants 1986, Hine et al. 1981, Merrell 1977, Roberts 1981, Seburn and Seburn 1998, Wershler 1992a). Temporary ponds and shallow lakes that are unsuitable for fish, and that contain water until late July or August are considered to be the most favourable spawning sites for northern leopard frogs (Hine et al. 1981, Merrell 1977, Roberts 1981, Souder 2000). Most breeding ponds contain a mixture

of open water and emergent vegetation, although at some sites in Alberta, breeding ponds are totally encompassed by emergent vegetation (Wershler 1992a). Leopard frog tadpoles are generally poorly adapted to cope with currents and thus can develop successfully only in the slow reaches of streams or backwaters (Roberts 1981).

Following breeding and transformation, adult, juvenile and young-of-the-year (YOY) frogs move to summer feeding areas. Most often, these areas are located along the margins of water bodies (Hine et al. 1981, Merrell 1977, Wershler 1991a). Smaller, immature frogs appear to be more closely tied to water; adults will occasionally venture some distance from water in the summer (Dole 1965b, Merrell 1977, Seburn 1994, Wershler 1991a). This difference may be related to the greater surface-area-to-volume ratio of smaller frogs, which makes them more prone to desiccation (Seburn 1994).

Preferred summer feeding habitat generally consists of open and semi-open areas with short vegetation (Cottonwood Consultants 1986, Dole 1965a,b, Merrell 1977, Wershler 1992a). Areas lacking vegetation or with closely clipped vegetation, such as found on heavily grazed pasture, are avoided by frogs (Merrell 1977). Areas with tall, dense marsh vegetation, grasses or extensive shrub cover are also avoided, particularly by smaller frogs (Merrell 1977). In Minnesota, Merrell (1977) noted that northern leopard frogs were seldom found in heavily wooded areas away from water. Seburn (1994), however, found no difference in the density of frogs occupying wooded versus non-wooded habitats in the Cypress Hills of southeastern Alberta.

Unlike most of Alberta's other species of amphibians, northern leopard frogs overwinter in water (Russell and Bauer 2000). Overwintering frogs require well-oxygenated water that does not freeze to the bottom during winter (Hine et al. 1981). Hibernacula are most often located in springs, streams, spillways below dams, or in deeper lakes and ponds (Cunjak 1986, Emery et al. 1972, Merrell 1977, Roberts 1981). Frogs have been found hibernating under rocks, logs, leaf litter or vegetation, or in depressions in sand or mud (Emery et al. 1972). Shallow breeding ponds and lakes are unsuitable for overwintering because of the depletion of oxygen in the water column, which can lead to winterkill (Babin and Prepas 1985). In southern Alberta, springs appear to provide critical overwintering habitat during periods of drought when deeper permanent water sources become scarce (Wershler 1991a).

Currently, detailed assessment of habitat availability at occupied and vacant sites is limited, with no identified trends. Drought conditions over recent years in many areas of the leopard frog's current range could potentially compromise overwintering habitat as well as breeding habitat, which could dry up before metamorphosis is complete. Conversely, flooding of breeding habitat can adversely affect egg mass deposition and tadpole development by washing egg masses and tadpoles into unfavourable habitat and eliminating shallow water zones that favour the growth and development of the tadpoles.

CONSERVATION BIOLOGY

The northern leopard frog is a member of the Family Ranidae, or "true frogs." As with most species in this family, the leopard frog possesses powerful hind legs and extensively webbed hind feet that are well adapted for jumping and swimming. Key diagnostic characteristics of the leopard frog include a pair of continuous white or cream-coloured dorsolateral ridges that extend from behind the eye to the lower back near the groin. In addition, the back, side and legs of the leopard frog have numerous, irregularly placed, round or oval dark spots with light borders. Typically, the background colour of the leopard

frog ranges from various shades of green to brown or tan. Adult female leopard frogs may obtain a snout-to-vent length of 110 mm, with adult males being somewhat smaller (Hine et al. 1981, Nace et al. 1996, Russell and Bauer 2000).

Northern leopard frogs emerge from overwintering sites shortly after the ice begins to melt. Merrell (1977) suggests that increasing water temperatures act as a stimulus, causing hibernating frogs to become more active and to move from deeper overwintering areas to shallower water areas along the shore. Pace (1974) noted that migration from overwintering sites begins when water temperatures reach 9° to 12°C. Merrell (1977) observed that frogs did not leave their hibernacula until the air temperature exceeded 13°C, or rose above the temperature of the water. Overland migrations of up to 1.6 km may be made between overwintering sites and breeding ponds (Hine et al. 1981, Souder 2000).

The timing and duration of breeding also appear to be temperature-dependent. In Alberta, breeding occurs from late April to late June and breeding behaviour may occur while ice is still on ponds (Wershler 1992a). Yaremko (1994) observed males calling in early May in southern Alberta when the air temperature was 17.3°C and the water temperature was 14.8°C. Cooler air temperatures can temporarily suppress breeding activity, resulting in two or more mating periods and several size classes of larvae (Hine et al. 1981, Merrell 1977).

Sexually mature males arrive at the breeding pond first and call while floating on the surface of the water. Males typically congregate in small groups in the warmest parts of the breeding ponds. Sexually mature females are attracted to the calling of the males and arrive within a few days to a few weeks after the males (Hine et al. 1981). Egg laying occurs shortly thereafter. Egg masses are typically laid in shallow water on vegetation, branches, and, rarely, on the pond bottom (Corn and Livo 1989, Hine et al. 1981, Merrell 1977, Seburn 1992a, 1993, Yaremko 1994).

The sexual maturity of the leopard frog is most likely reached at a particular size, rather than a definite chronological age. Generally, most leopard frogs become sexually mature in their second year, although this can vary depending on ambient environmental conditions that affect growth rate (Gilbert et al. 1994). Females are believed to produce only one clutch per year (Corn and Livo 1989, Crouch and Paton 2000) and it is thought that all eggs are laid in one mass (Gilbert et al. 1994, Noble and Aronson 1942). Egg masses may contain between 600 and 7000 eggs (Corn and Livo 1989). Female body size has been positively correlated with clutch size in most anurans (Slathe and Duellman 1973 cited in Corn and Livo 1989). Corn and Livo (1989) suggested that the frequency distribution of clutch size could be used as a method to determine age structure of breeding females in northern leopard frog populations.

The time of hatching is variable and is also dependent on water temperature (Russell and Bauer 2000). For example, Hine et al. (1981) observed hatching five to nine days after egg laying, and found that cool weather extended the hatching time. Merrell (1977) found that hatching success was greater in egg masses located below the surface of the water relative to egg masses laid on the surface. Eggs can be lost to parasites, disease or other factors (Hine et al. 1981). Hatching success can also vary greatly between individual egg masses. High mortality of eggs, including failure of entire clutches, can result from flooding, droughts or periods of cold temperatures (Corn and Livo 1989).

Tadpoles remain close to egg masses after hatching, but disperse after a few days (Eddy 1976). Several environmental, biotic and abiotic factors influence tadpole growth and development, including temperature, density,

diet, pH, predator interactions and dissolved oxygen (McDiarmid and Altig 1999). The length of time to metamorphosis ranges from 60 to 90 days and may occur over several weeks at a single site (Wershler 1991a). Survivorship, from total egg to metamorphosed young, averaged 3% in Minnesota (Merrell 1977), and from 1% to 6% in Wisconsin (Hine et al. 1981). Mortality, however, can be complete if breeding ponds dry up before tadpoles become fully transformed (Hine et al. 1981, Merrell 1977). In Alberta, metamorphosis generally occurs in July and early August (Seburn 1992a, 1993, Wershler 1991a, Yaremko 1994); however, cool weather can delay the development and metamorphosis of tadpoles well into September (Seburn 1993).

Tadpoles feed on floating vegetation and detritus. At metamorphosis, frogs become carnivorous, taking only moving prey. Their diet includes insects, arachnids and other small invertebrates, as well as small birds, garter snakes, frogs and fish (Hine et al. 1981, Moore and Strickland 1954, Rittschof 1975, Russell and Bauer 2000). Although rarely, adults will also cannibalize newly transformed young (Russell and Bauer 2000, Wershler 1992a).

Annual adult mortality has been estimated to be approximately 60% (Merrell and Rodell 1968). Mortality rates of immature frogs are also relatively high. The ratio of YOY frogs to sexually mature frogs ranged from about 15:1 to 20:1 in Minnesota (Merrell 1977). Similar values were reported in Wisconsin (Hine et al. 1981). In Alberta, Seburn (1994) observed ratios of approximately 120:1 in a breeding population in the Cypress Hills. In 1994, overwintering mortality of YOY frogs in this same population was estimated at 93% (Yaremko 1994). This estimate may, however, be high because it was based on the assumption that there was little dispersal from natal areas (C. Paszkowski, pers. comm.). The longevity of the leopard frog in captivity is up to 9 years (Froom 1982, Russell and Bauer 2000). Leopard frogs exceeding 4-5 years of age were found to represent only a tiny fraction of a wild population from southwestern Quebec, based on one skeletochronology study (Leclair and Castanet 1987).

Following breeding, adults may remain in the vicinity of breeding ponds or disperse to summer feeding ranges (Eddy 1976, Hine et al. 1981, Merrell 1977, Seburn 1993). Typically, these feeding ranges are located near water. Adults appear to establish home ranges in the summer (Dole 1965a,b, Hine et al. 1981). Home range size is dependent on the availability of appropriate habitat (Dole 1965b). In late summer or early fall, adults begin to migrate from summer feeding areas to overwintering sites (Eddy 1976, Merrell 1977). Roberts (1981) reported that northern leopard frogs are active in Alberta until October and, exceptionally, into November. Little is known about the overwintering ecology of northern leopard frogs; however, limited information suggests that a relatively high dissolved oxygen level (7 ppm +) and low water temperatures (< 4°C) are required (Cunjak 1986, Hine et al. 1981, Nace et al. 1996).

Following transformation, YOY frogs disperse away from natal ponds. In Michigan, Dole (1971) found that YOY frogs could disperse up to 800 m per night. In addition, he recaptured two adults 5 km from their natal pond, and noted that this distance could have only been travelled over land. In the Cypress Hills, YOY frogs dispersed up to 2.1 km from natal ponds along aquatic corridors (Seburn et al. 1997); however, the greatest distance travelled over land was 0.4 km. One of the frogs marked as a YOY in 1993 was recaptured in 1994 at a distance of 8 km from the natal pond.

DISTRIBUTION

1. Alberta. - Northern leopard frog populations experienced drastic declines in Alberta near the end of the 1970s (see Population Size and

Trends). These declines in population were accompanied by changes in distribution in the province. Accordingly, descriptions of the distribution of northern leopard frogs in Alberta are divided into "historical" and "current," based on whether observations were collected before or after 1980.

Many biologists (Cook 1984, Schueler 1982, Stebbins 1951, Wright and Wright 1949) have shown the historical distribution of the northern leopard frog to be continuous in Alberta, with the range including most of southern Alberta and a band running along the eastern border of the province north to the Northwest Territories. However, a review of museum collections (Appendix 2), naturalists' records and published sources of information (Appendix 3) suggests that the species' range was largely restricted to two discontinuous parts of the province. These two areas include the Slave River valley and Kazan Upland Subregion in extreme northeastern Alberta, and the Grassland, Parkland and Foothills Natural Regions of southern Alberta* (Figure 1).

The occurrence of the species in northeastern Alberta is based on published accounts from the Slave River at Fitzgerald Settlement (Smith Landing) and Fort Smith near the turn of the twentieth century (Preble 1908). Other records also exist from nearby sites in Saskatchewan and the Northwest Territories (Harper 1931a, Hodge 1976, Logier and Toner 1961, Museum of Zoology, University of Alberta, unpubl. data). There is also a museum specimen from the Rocher River at the western end of Lake Athabasca (Appendix 2 - specimen NMC593), but it is likely that catalogue information for the specimen is in error. This specimen was collected by F. Harper, but he does not mention the specimen in subsequent reports about his trips in the area (Harper 1931a,b). The collection date for the specimen, 5 August 1914, also corresponds to the date that northern leopard frogs were collected at the Natla Rapids on the Talston River, Northwest Territories (Harper 1931a). Considering these factors, it is likely that the specimen was actually collected at the Talston River and not at the Rocher River (F. Cook, pers. comm.).

In the southern half of the province, the species' range extended across the Grassland, Foothills and Parkland Natural Regions from the U.S. border north to Edmonton. Within these regions, the northern leopard frog was continuously distributed along major rivers and tributaries with scattered populations associated with lakes, springs and irrigation reservoirs. Although the species appears to have been widely distributed in the western half of the central Parkland, there are only a handful of records from the eastern portion of the Parkland north of the Battle River.

In southern Alberta, the western extent of the range was the Foothills and the eastern periphery of the Rockies at lower elevations. Historical records exist from the northeastern and eastern edges of Waterton Lakes National Park and from the Bow Valley corridor near Bow Valley Provincial Park and the Yamnuska Centre (Appendix 2 and 3, Salt 1977). Historical records from the mountains are lacking (Bow Valley Naturalists 1978, Holroyd and Van Tighem 1983, McIvor 1994, McIvor and McIvor 1995 and 1996 - Banff National Park and Bow Valley Corridor; Holroyd and Van Tighem 1983 - Jasper National Park; C. Wershler pers. comm. - Waterton Lakes National Park; Salt 1977 - Kananaskis Country) and Salt (1979) considered the species to be of "hypothetical" occurrence in Alberta's Rockies. It should be noted, however, that many of the amphibian surveys from the Rocky Mountains were conducted after abrupt population declines were observed elsewhere in the province. Salt (1979) also mentions a museum specimen collected near Jasper, but this record could not be located.

* To view a current map of Alberta's Natural Regions and Subregions visit the Alberta Natural Heritage Information Centre (ANHIC) web site: (http://www.cd.gov.ab.ca/preserving/parks/anhic/natural_regions_map.asp)

Figure 1. Known observations and collection sites for northern leopard frogs in Alberta prior to 1981. See Appendices 2 and 3 for descriptions of sites.

The true distribution of the leopard frog north of 55°N is poorly known and there are few historical records from north of Edmonton (Russell and Bauer 2000). It should be noted, however, that the National Museum of Canada and the University of Alberta (in 1976, W. Roberts, pers. comm.) both made extensive amphibian collections in northern Alberta, but did not encounter leopard frogs. In some areas, extensive biophysical surveys also failed to locate the species (e.g., Roberts and Lewin 1979). Although information on the historical distribution of herpetofauna in northern Alberta is largely lacking, existing data suggest that the northern leopard frog was locally and sparsely distributed in the boreal forest.

North of Edmonton, museum specimens have been collected at Valleyview, Whitecourt and at sites along the Smoky River that were initially identified as having northern leopard frogs (Appendix 2). These specimens are tadpoles, which can be difficult to identify. A recent preliminary examination of the specimens indicated that they may have been misidentified (F. Cook, pers. comm.). Until further confirmation, these records must be considered dubious. There is also a specimen record (USNM 9343) from the late 1880s with the site locality of "Athabaska River, British America R" (Yarrow 1882, pg. 179; Cope 1889, pg. 403). Northern leopard frogs have also been observed along the Lesser Slave River (Wershler 1991a), at Lesser Slave Lake Provincial Park (Griffiths 1976, cited in Bradley 1980), and at Thunder Lake, Long Lake and Cross Lake provincial parks (Spalding 1980, Wershler 1991a). It should be noted, however, that Griffiths does not mention northern leopard frogs in her account of the wildlife of Lesser Slave Lake Provincial Park presented in Spalding (1980). The Fort Smith site location shown in Cottonwood Consultants Ltd. (1986), Alberta Fish and Wildlife (1991a) and Wershler (1991a) is based on an unconfirmed sighting reported to Roberts and Lewin (1979).

Since 1980, there has been a southern contraction of the provincial range of the northern leopard frog. The species now appears to be largely extirpated from the west and central portions of the Parkland Natural Region, and is absent from the North Saskatchewan River drainage, with the exception of a reintroduced population in the upper reaches (W. Roberts, pers. comm.). A single observation in 1999 was recorded along the Battle River near Wainwright, Alberta. The site was reinvestigated in 2000 but yielded no observations. Leopard frogs were observed and heard calling at two locations approximately 10 km north of Onion Lake, Saskatchewan. These sites are located near the Alberta border and just north of the North Saskatchewan River (K. Saker, pers. comm.), suggesting that increased monitoring in that region of Alberta may result in additional frog observations. Recent records from northeastern Alberta include observations at Bocquene Lake in 1991 (K. Wingert, pers. comm.) and 1997 (M. Steinhilber, pers. comm.), from Wylie Lake in 1983 and 2000 (Kendell 2002b, Wallis and Wershler 1983), Leland Lake in 2000 (Kendell 2002b) and Darwin Lake in 1996 (M. Steinhilber, pers. comm.) and 2001 (Gammon 2001). Apart from the above-mentioned record near Wainwright, the reintroduced population, and the Kazan Uplands in northeastern Alberta, there have been no observations of northern leopard frogs north of the Red Deer region since 1979.

1990-1991 Inventory: In 1990 and 1991, extensive surveys were conducted at sites in southern Alberta where northern leopard frogs were known to occur historically, or where there had been recent unconfirmed sightings of the species (Hofman 1991, Seburn 1992a, Wershler 1991a, 1992a). These surveys revealed that leopard frog populations were locally abundant at three sites in the Cypress Hills, along the Milk and South Saskatchewan rivers, along the lower reaches of the Bow and Red Deer rivers, and at sites along the Little Bow River, and Canal and Manyberries creeks. Many sites were visited only once, and for a limited amount of time,

making population estimates at each site difficult. Leopard frogs were also found to be present at a few sites in the central Parkland near Red Deer. Population surveys conducted at the proposed Suffield National Wildlife Area from 1994 to 1996 located additional populations along the South Saskatchewan River (A. Didiuk, pers. comm.). Since 1990, additional populations have also been discovered along Willow Creek (D. A. Westworth and Associates 1993), along the Red Deer (R. Lauzon, pers. comm.), Milk (L. Powell, pers. comm., Wershler and Smith 1996) and Sheep (Alberta Amphibian Monitoring Program, unpubl. data) rivers, and along an irrigation drainage near Bow City. See Appendix 4 for sightings of northern leopard frogs in Alberta between 1981 and 1996.

2000-2001 Inventory: Since 1990-1991, no province-wide survey had been conducted to assess the distribution and status of extant populations of leopard frogs in Alberta. In order to re-evaluate the current status of leopard frogs, a two-year inventory project was initiated in 2000 and completed in 2001 (Kendell 2002b). The primary objectives of the inventory were to do the following: (1) determine occurrence of frogs at the historical sites; (2) determine breeding success, if possible, at occupied sites; (3) determine relative abundance at occupied sites; and (4) evaluate a trend in occupancy at sites, compared to survey results of Wershler (1991a). A standard survey protocol, outlined in Kendell (2002a), was developed to increase the efficiency and productivity of surveys.

Information on 297 historical and recent sites was compiled using the Biodiversity Species Observation Database (BSOD). Maintained by the Fish and Wildlife Division, Alberta Sustainable Resource Development, BSOD stores observational data primarily on species at risk or of undetermined status. Of the known sites, 269 were chosen for investigation and leopard frogs were observed at 54 of those sites. Leopard frog observations were closely associated with major river drainages, including the Oldman, the lower Red Deer, the Milk, the South Saskatchewan and the lower Bow. Leopard frogs were also found at sites in the Cypress Hills region of Alberta, Willow Creek drainage (just west of Stavely) and in the extreme northeast region of Alberta (Figure 2).

Leopard frogs were most commonly encountered east of Highway 2 and generally south of the latitude of Drumheller (51.28°) (Figure 2). A relatively isolated population occurs in the Willow Creek drainage. A substantially more isolated population occurs east of Wood Buffalo National Park in the extreme northeast region of the province (Figure 2). Major sites (combined total of 10 or more adult and subadult frogs observed) occurred in the Cypress Hills region, at Prince's Spring, and in the lower Milk and Red Deer river drainages.

Survey results indicate that the leopard frog has experienced additional local extirpations over the last decade (Kendell 2002b). Leopard frogs were not found at 33% of the occupied sites that were identified by Wershler (1991a), and results of the inventory indicate the possible further extirpation of leopard frogs from sites located south of Lethbridge, as well as south and west of Calgary, between 1990 and 2001 (Kendell 2002b). In addition, results from the inventory also indicate that the distribution of the leopard frog is similar to that described by Wershler (1991a), Wagner (1997) and Seburn and Seburn (1998) and that the species has not re-colonized formerly occupied areas of its range.

The area of occupancy of the leopard frog in Alberta is difficult to estimate, but a minimum area can be extrapolated from the data collected during the 2000-2001 inventory. This can be estimated based on the number of occupied sites and the studied migration and dispersal distances of the northern leopard frog. Leopard frogs are known to move between 1.6 km (Hine et al. 1981, Souder 2000) and 2.0 km (Russell and Bauer 2000) in a single active season. This ability to travel suggests that the area of

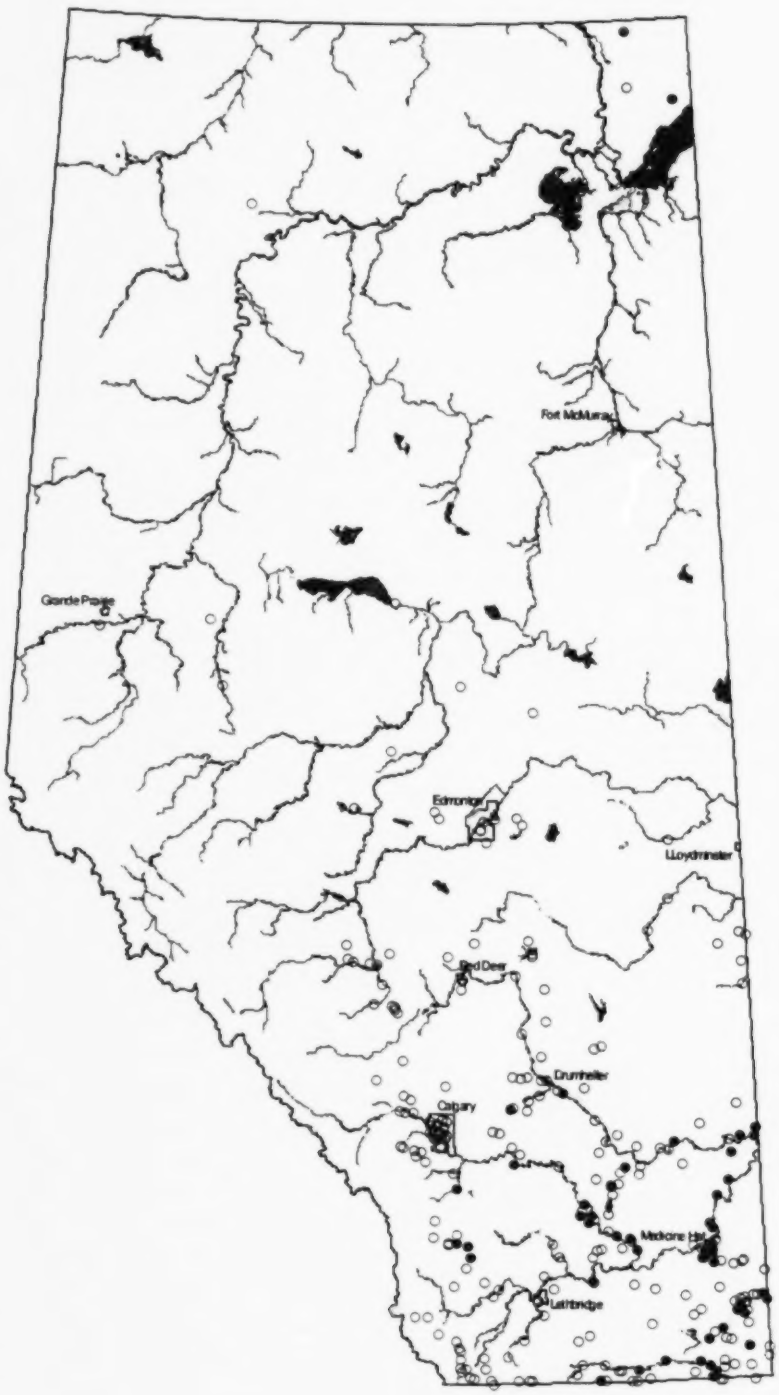

Figure 2. Sites where one or more northern leopard frogs were observed (solid circles) and sites where no leopard frogs were observed (open circles) during the 2000-2001 Alberta inventory. See Kendell 2002b for descriptions of the sites.

occupancy for leopard frogs found at any given specific site might be up to 12.6 km^2, if suitable habitat is present. If this holds true, the current area of occupancy of leopard frogs in Alberta can be estimated to be up to 680 km^2, based on the 54 occupied sites in 2000-2001. This assumes that individual frogs in all 54 populations travel up to 2.0 km between habitats, over the season.

It should be cautioned that many of the leopard frog records held in BSOD (and subsequently investigated during the inventory) were associated with areas of the province with good public access, near rural or urban centres, or other areas frequented by people. In addition, the absence of leopard frogs at some sites may only reflect the inability of observers to detect them at the time of survey. Therefore, the range interpreted from the data collected during the inventory may underestimate the occurrence of leopard frogs elsewhere in the province and potentially at investigated sites where no frogs were observed at the time of survey. In addition, a number of areas of the province were not surveyed but could potentially support leopard frogs. As a result, the estimated area of occupancy of 680 km^2 should be considered a minimum.

2. Other Areas. - The northern leopard frog is widely distributed over much of central North America (Figure 3), and with the exception of range contractions resulting from local extirpations of breeding populations (particularly in western North America), the current and historical ranges are generally similar. The species is broadly distributed across the southern half of Canada east of the Rockies. The range extends as far north as south-central Northwest Territories, and a disjunct population occurs in southern Labrador (Cook 1984). In eastern British Columbia, the leopard frog occurs in the vicinity of Creston at the southern end of Kootenay Lake (Orchard 1992, D. Adama, pers comm.), but has been extirpated from the Kootenay River valley. The species was also successfully introduced on Vancouver Island and Newfoundland (Cook 1984, Green 1978). However, the Vancouver Island population of leopard frogs is now extirpated (D. Adama pers. comm.).

In the United States, the species' range extends from eastern Montana, southern Idaho, northeastern California, Arizona and extreme southern New Mexico to the continental divide. Remnant populations also occur in western Montana, Washington and Oregon. East of the continental divide, the species' range extends across the northern plains states, and east through the Ohio Valley to New England (Baxter and Stone 1980, Russell and Bauer 2000, Stebbins 1951).

POPULATION SIZE AND TRENDS

1. Alberta. - Until recently, the herpetofauna of Alberta has received little attention from either scientists or naturalists (Russell and Bauer 1993, Wershler 1991a). Leopard frog population surveys were not conducted before the 1980s, and there is little formal documentation of historical population levels in the province. Knowledge of the historical distribution and abundance of the species is largely based on biophysical inventories in specific areas of the province, museum collections, and the records and recollections of naturalists. These sources indicate, however, that northern leopard frogs were historically common south of Edmonton, as well as south and west of the Battle River (Cottonwood Consultants 1986, Roberts 1981, 1987, 1992, Russell and Bauer 2000, Wershler 1991a). Documented reports indicate that the species was common in southeastern Alberta (Lewin 1963), along the Milk River valley (Wallis 1976), in the Cypress Hills (Halladay 1965), at several natural areas in Calgary (Bird 1973, 1974, Pinel 1980), south and west of Red Deer along the Raven and Red Deer rivers and Kneehill Creek (Roberts 1981), and along Kilini Creek west of Edmonton (W. Roberts, pers. comm., Spalding 1980).

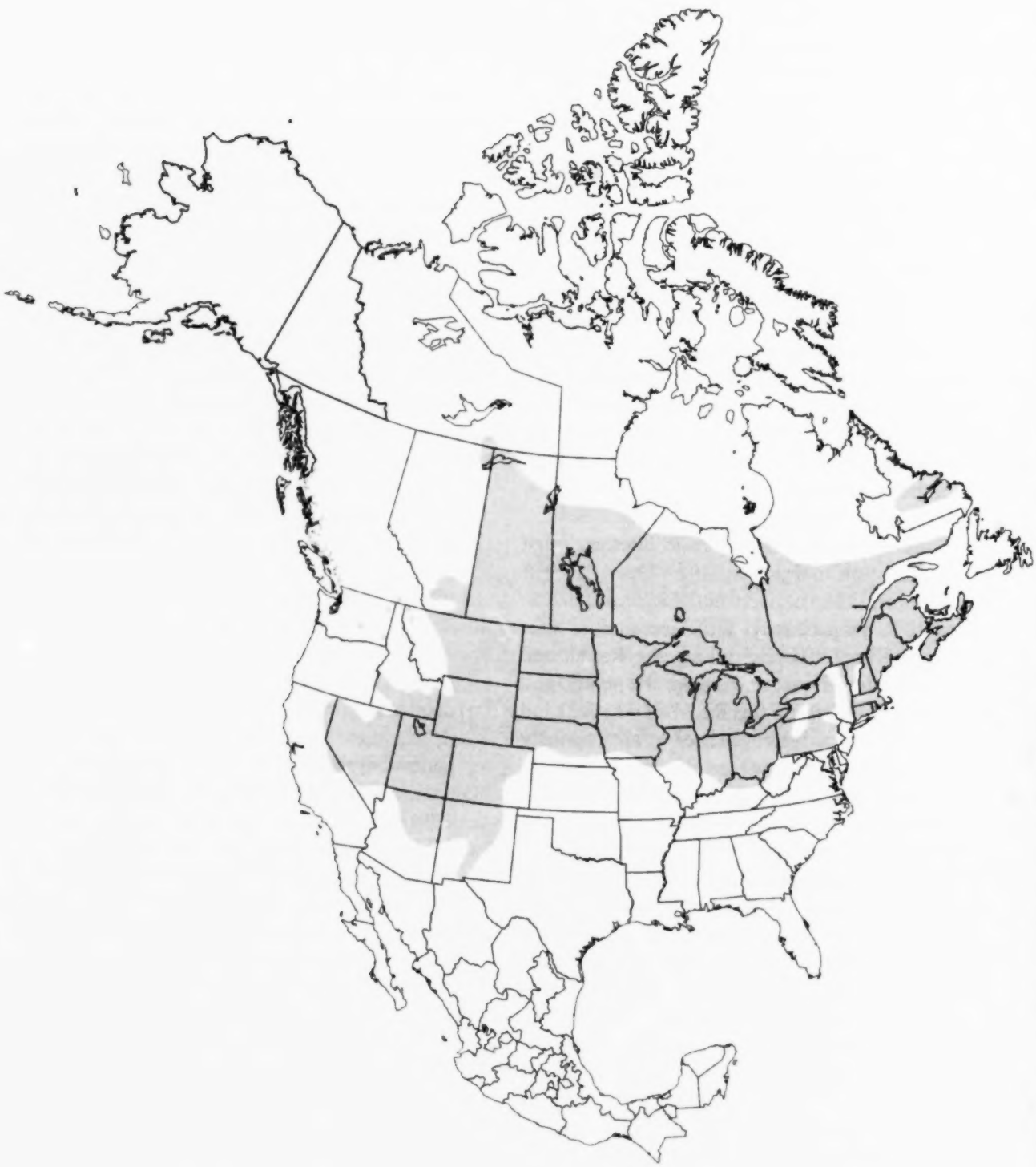

Figure 3. North American range of the northern leopard frog (adapted from Stebbins 1985, data in Kendell 2002b, as well as state and provincial species experts and web sites).

Specimen records held at the National Museum of Canada and University of Alberta Museum of Zoology, also reveal that leopard frogs could readily be collected at a number of locations in small geographical areas in the prairies and foothills of southern Alberta during the 1950s and 1960s. Extensive field surveys conducted in southern Alberta in the 1970s indicated, however, that relative to the boreal chorus frog (*Pseudacris maculata*), leopard frogs were only locally abundant (Wershler 1991a). This is likely related to the species' need for well-oxygenated overwintering sites (Lewin 1963). In summary, although quantitative survey data are lacking, the information that does exist indicates that northern leopard frogs were historically widely distributed but locally abundant south of Edmonton, and south and west of the Battle River.

In Alberta, abrupt population declines were first noted south and west of Red Deer in 1979 (Roberts 1981). Between 1976 and 1978, northern leopard frogs were abundant at sites along Kneehill Creek, along the Raven and Clearwater rivers, and along the upper and middle reaches of the Red Deer River, and populations were reproducing successfully (Roberts 1981). However, extensive searching in the area in 1979 and 1980 failed to locate any leopard frogs (Roberts 1981), and ongoing annual surveys have not yielded subsequent records in these areas (Roberts 1987, 1992, 1994, pers. comm.). A similar pattern has been noted in Calgary, where annual monitoring of natural areas within the city by the Calgary Field Naturalists Society has not produced records of northern leopard frogs since the late 1970s (M. Babey, pers. comm.). In 1979, extensive searches were also conducted at other sites where leopard frogs had been known to occur, but only one individual was found and it was overwintering in the Milk River (Wershler 1991a). At the same time, naturalists, scientists, fishermen and farmers in southern Alberta were queried as to whether they had seen any leopard frogs. These enquiries yielded no recent records, although many of the people recalled that the species was previously abundant in many areas (Roberts 1987).

It is unknown when population declines first began in southern Alberta, but declines appear to have occurred in many areas by at least the early- to mid-1980s (Cottonwood Consultants 1986, Roberts 1981, 1987, Wershler 1991a). Between 1979 and 1989 there were few reports of northern leopard frogs from anywhere in the province. In the early 1980s, naturalists were asked to increase their surveillance of reptile and amphibian populations in Alberta (Roberts 1981, 1982), but few reports of leopard frogs resulted. Many of the reports that did come in turned out to be other species (Wershler 1991a). Field surveys conducted in southern Alberta in the early- and mid-1980s revealed that leopard frogs were absent from many historically occupied sites and, where they did exist, populations were greatly reduced from historical levels (Cottonwood Consultants 1986, Roberts 1987, Wershler 1991a). Through these surveys, a few individuals along the St. Mary's River and Pinepound Creek were located, and locally abundant populations were found at Prince's Spring (near Bindloss), along the Milk River, and along the lower Bow River (Cottonwood Consultants 1986, Roberts 1987, Wershler 1991a).

Censusing amphibian populations can be problematic and populations can fluctuate widely between years (Pechmann et al. 1991), so caution must be exercised when comparing population trends between sites and between years. Data limitations also make it somewhat difficult to identify long-term population trends in the province. At some locations there are long-term, qualitative data that indicate dramatic population declines have occurred over the last 25 years. However, elsewhere in southern Alberta, population trends have largely been determined from surveys conducted in 1990, 1991, 2000, and 2001 at locations where historical occurrence was recorded from

museum specimens, naturalists' records or published accounts in the literature (Hofman 1991, Kendell 2000b, Seburn 1992a, Wershler 1991a, 1992a).

The occurrence data collected during the most recent inventory in 2000 and 2001 do not allow for an accurate assessment of the population size at the sites investigated. This is because time constraints and the large geographic area surveyed meant that each site could only be visited once and for a limited amount of time. Corn (1994) notes that there can be some problems with using such surveys to determine long-term population trends. First, single site visits may fail to detect individuals that are actually present, which would result in an overestimation of population declines (Corn 1994). For example, during the breeding season northern leopard frogs may not call on a certain day or at certain times of the day (Cook 1994) and breeding populations may go undetected during brief, single call surveys at a site. After the breeding season, adults may also be difficult to find because they disperse away from breeding ponds (Corn 1994) or may only be active under particular environmental conditions. Second, the use of museum, naturalists' and published records may not provide an accurate baseline of historical population levels, and may ignore population trends resulting from the natural processes of local extinction and recolonization (Corn 1994). This is particularly true if records are combined over several decades. Furthermore, museum records and anecdotal accounts do not always represent breeding populations, or they may represent records from marginal habitats where breeding may occur but is rarely successful (Corn 1994).

Giving due consideration to data limitations, it is still apparent that northern leopard frog populations have declined dramatically in southern and central Alberta over the last 25 years.

2. Other Areas. - Northern leopard frogs have long been used as laboratory and research animals in North America and wild frogs have traditionally supplied this market. Beginning in the early 1960s, harvesters for biological supply houses noted sudden and dramatic declines in leopard frog numbers in many localities in the midwestern U. S. and California (Gibbs et al. 1971, Hine et al. 1975). Biological supply houses also observed a general decline in the health of the animals (Gibbs et al. 1971, Hine et al. 1975). Frogs often died in holding tanks before they could be shipped to customers, and it was not uncommon for 50% to 90% of the frogs to die from a septicemia resulting from infection with the bacterium *Aeromona hydrophila*. This was not surprising as most frogs were placed under a great deal of stress between the time of capture and delivery to end users, and were probably very susceptible to disease (Gibbs et al. 1971). Approximately 5% to 10% of the frogs caught in the northeastern and north-central U. S. also had kidney tumours (Gibbs et al. 1971). Based on the difficulty of obtaining frogs for laboratory use and reports of frog declines from harvesters, Gibbs et al. (1971) estimated that northern leopard frog populations declined by 50% in the U. S. during the 1960s. They blamed the decline on overzealous harvesting and habitat loss.

The abrupt and widespread population declines previously described for Alberta appear to have been paralleled over much of the species' range in the upper midwestern states and prairie provinces during the 1970s. The initial declines were noted in centres of high frog densities in the upper midwest states, most notably in Michigan, Minnesota, Wisconsin and South Dakota in the late 1960s and early 1970s (Hine et al. 1975, 1981, Rittschof 1975). The die-off spread rapidly and, within a year or two, declines of northern leopard frogs and other related species of leopard frog were noted as far south as Mexico (Koonz 1992).

Abrupt population declines occurred shortly afterward in Manitoba (Hine et al. 1981, Koonz 1992, Wershler 1991a). Traditionally, the northern leopard frog harvest in Manitoba comprised a large portion of the North American market, with as much as 50 000 kg of frogs being shipped annually to biological supply houses in the U.S. (Koonz 1992). By 1976, no exports were made and leopard frog had virtually disappeared from the province, particularly from areas that formerly supported the greatest densities of frogs, such as Lake Manitoba (Koonz 1992). Windrows of dead frogs were observed on shorelines along Lake Manitoba and piles nearly a metre high were noted in artesian wells ("frog holes") used as hibernacula. Small, isolated populations (e.g., on golf courses, stock ponds and islands) survived through to 1983, when some recovery was noted and exports resumed at much-reduced levels (Koonz 1992). Since then, northern leopard frog populations have increased in some areas, while remaining extremely low in others (Koonz 1992, B. Watkins, pers. comm.). Although northern leopard frogs have moved back into much of their traditional range, they have not approached historical population densities in Manitoba.

From Manitoba, the die-offs apparently spread westward. As in Alberta, there are few data on the historical distribution and abundance of northern leopard frogs in Saskatchewan. However, available data suggest that population levels reached a low in the early- to mid-1970s (Seburn 1992b). Over the last 10 years there has been an increased number of reports in Saskatchewan, which suggests that the species may be increasing locally (A. Didiuk, pers. comm.). In many areas, however, population densities are still low relative to historical levels (W. Harris, pers. comm.). It should also be noted that increased reporting in recent years may also be related to increased interest in the species, brought about by the establishment of the Saskatchewan Amphibian Monitoring Project and Saskatchewan Herpetology Atlas Project. Major population increases have been noted recently in some areas of Saskatchewan. In the late 1980s, for example, northern leopard frogs were difficult to find in Grasslands National Park (W. Harris, pers. comm.). However, in 1991 the species was found to be common in many areas of the park (W. Roberts, pers. comm.) and in 1995 and 1996, it was observed to be common along both the Frenchman River valley and along Rock Creek (L. Powell, pers. comm.). Various age classes, including a large number of adults were recorded during the 1995 and 1996 surveys.

Recent population surveys have been conducted over much of the historical range of the northern leopard frog in the Kootenay and Columbia River valleys of southeastern British Columbia (Ohanjanian and Teske 1996, I. Ohanjanian, pers. comm., Orchard 1992, Waye and Cooper 2001). However, frogs have only been found within one locality near Creston, the Creston Valley Wildlife Management Area (D. Adama, pers. comm., I. Ohanjanian, pers. comm., Orchard 1992, Waye and Cooper 2001). Populations appear to be extirpated in the Okanagan Valley (Cannings et al. 1999). The exact timing of the declines in British Columbia is unknown, but they appear to have occurred in the 1970s and 1980s (Waye and Cooper 2001). The cause of the decline is unknown, but in some areas it may be related to habitat loss (Orchard 1992).

Recent major population declines have not been noted in eastern Canada (Bishop and Petit 1992), but Gilbert et al. (1994) noted that local population declines have occurred in Quebec because of habitat loss.

Population declines have been reported from a variety of other jurisdictions in the western U.S. As was the case in Alberta, most populations have been poorly studied and there is a lack of historical data. Most declines have also been noted after the fact, so attributed causes for the declines have been based more on correlative rather than experimental evidence (Corn 1994). To date, researchers have not linked the declines

observed in the western U.S. with the abrupt and widespread population die-offs observed in the upper midwestern states and prairie provinces during the 1970s.

The northern leopard frog was formerly widely distributed across Montana, but is now absent over much of the western half of the state (J. Lichtenberg pers. comm., Reichel and Flath 1995). Authorities are aware of only two populations west of the Continental Divide in Montana (U.S. Department of Interior 2002). The species is still locally common in the southeastern corner of the state, but its status is uncertain in central and northeastern Montana (Reichel and Flath 1995). Population declines appear to have occurred over the last 10 to 15 years. Elsewhere in the western U. S., declines have been noted in eastern Washington (Andelman and McAllister 1994, Koch et al. 1996, Leonard and McAllister 1996), eastern Oregon and southern Idaho (Koch et al. 1996), Colorado and Wyoming (Baxter and Stone 1980, Corn and Fogleman 1984, Corn et al. 1989, Hammerson 1982, Wiese 1990), Nevada (Panik and Barrett 1994), Arizona and California (Clarkson and Rorabough 1989, Fernandez and Bagnara 1995, Hayes and Jennings 1986, Schwalbe and Rosen 1988, Sredl and Waters 1995).

LIMITING FACTORS

Over the last 30 to 50 years, amphibian populations have declined dramatically, and around the globe, a relatively large number of species are in jeopardy (Barinaga 1990, Blaustein and Wake 1990, Wyman 1990). This is true of many species found in Canada (Bishop and Petit 1992, Cook 1970, Quinn 1991), including the northern leopard frog. In this, and other, species, declines can often be explained in relation to natural population fluctuations (Pechmann et al. 1991), extremes in climatic conditions (Barinaga 1990) or anthropogenic factors such as habitat loss, acidification, contaminant releases and the introduction of non-native species (Baringa 1990). However, in many other cases the declines cannot be explained and have occurred in relatively pristine environments or in areas where there has been no recent obvious disturbance. Such declines are often characterized by abrupt, massive and widespread population declines of one or more species. At the same time, populations of other amphibian species occupying the same area and similar habitats show no signs of decline.

In the past few years, comprehensive research and monitoring programs have been initiated world-wide to determine the extent and cause(s) of amphibian declines. Among the factors being examined are disease, the reduction in the ozone layer and the accompanying increase in ultraviolet radiation, changing weather patterns and climatic extremes, acid rain and chemical contaminants, the introduction of exotic species, and habitat loss or fragmentation. The following section outlines factors that may be applicable to declines in northern leopard frog populations in Alberta. Although the focus of this section is on human-induced factors, a number of naturally occurring factors are also included because of their possible synergistic impacts with other factors.

1. Climate. - Climatic conditions have a major influence on northern leopard frog populations (Merrell 1977). In general, during wet years there will be an increase in the amount of breeding and overwintering habitat, allowing populations to expand and providing opportunities for dispersal and colonization of unoccupied areas of suitable habitat. In drier years, available habitat will diminish, causing a reduction in population levels. Some local populations will also become extirpated because of a lack of habitat. For example, drought in the 1930s caused a general decline in amphibian populations in southern Alberta (Fowler 1935). Drought has been suggested as a possible reason for the decline and disappearance of northern leopard frog populations in Washington, Oregon, Idaho, Montana and Colorado (Corn and Fogleman 1984, Koch et al. 1996).

During the late 1970s and 1980s, drought conditions prevailed over much of southern Alberta. The accompanying loss of wetland habitat probably caused general population declines and the extirpation of some local populations in that area during this period (Wershler 1991a). Drought, however, has been dismissed as the cause of the abrupt and widespread population declines observed in southern Alberta since 1979 (Roberts 1981, 1987, 1992, Wershler 1991a). These authors argue that a reduction in wetland habitat and reduced winter stream flows may explain the disappearance of frogs in some areas. However, it would not explain the simultaneous disappearance of frogs in spring-rich areas such as along Kilini Creek and the Clearwater River, or at deep-water overwintering sites at major lakes and reservoirs. These assertions, however, are based on limited data and there is a need for further research to determine the extent to which northern leopard frog populations are affected by climatic conditions in southern Alberta.

2. Disease. - Mass mortality of amphibians from disease is not uncommon and may be a natural feature of the biology of a species, or it may be induced by environmental stressors (Corn 1994, Crawshaw 1992). Amphibians are known to be susceptible to a variety of diseases, including many diseases of fish (Crawshaw 1992). Mortality in northern leopard frogs has often been associated with the condition called "red leg" (Gibbs et al. 1971, Hine et al. 1981, Koonz 1992), which is not a disease itself but rather a condition of kidney failure (Koonz 1992). It is often associated with infection by *Aeromona hydrophila*, a naturally occurring and widespread bacterium. Ordinarily, this pathogen only affects individuals whose immune systems have been weakened by stress, and not entire populations.

A recently discovered species of chytridiomycete fungus, otherwise known as "chytrid" fungus, has been found responsible for the decline of several amphibian species around the world. This fungus was first identified in 1998 by a team of scientists in pristine areas of Panama and Australia (Anderson 1998, Berger et al. 1998, U.S. Newswire 2000). Evidence of the fungus has also been detected in leopard frogs and boreal toads (*Bufo boreas*) collected in Alberta; however, the role that the fungus played in the death of the collected specimens is unclear (Bollinger pers. comm., Necropsy/ Biopsy report 2001). It is unclear how a chytrid infection kills its host. However, it is understood that this water-borne fungus can survive outside of the host specimen on keratinized material and reproduce saprophytically (using dead or decomposing matter) (Daszak et al. 1999).

Further research has discovered that fungus outbreaks, caused by lethal infections of a pathogenic oomycete, *Saprolegina ferax*, have led to high amphibian embryo mortality. This fungus targets the developing embryos of frog and toad eggs at oviposition sites that are located in very shallow water. Under such water conditions, the eggs are afforded reduced protection against the exposure of UV-B radiation, which has been found to decrease their ability to resist infection by the fungus (Kiesecker et al. 2001a). Although this fungus has not been documented in Alberta, it has recently been linked to leopard frog egg mortality in British Columbia (D. Adama, pers comm.).

Finally, overwintering mortality in northern leopard frogs has also been attributed to a herpes virus (Lucke tumour virus) that causes renal carcinomas (Hunter et al. 1989, McKinnel 1973, 1980).

Roberts (1994) suggests that the pattern of decline observed in the upper midwestern states and the prairie provinces "was like that expected if a plague started in the east and spread across the continent." However, there is little conclusive evidence that disease was responsible for the abrupt and dramatic population declines observed in Alberta and elsewhere (Hine et al.

1981). The lack of calling males in the Red Deer area during the spring of 1979 suggests that mortality occurred in the previous fall or winter (Roberts 1981). This is similar to the pattern of mortality observed in Wisconsin (Hine et al. 1981). Incidences of overwintering mortality were noted in the Clearwater River in 1976 (Roberts 1992). Similar to other locations, mortality in the Clearwater River was associated with the condition of "red leg." In this case, however, only individuals were affected and healthy populations persisted in the area for the next two years.

3. Habitat Fragmentation. - Habitat fragmentation can affect leopard frog populations at two levels. Locally, populations are dependent on the juxtaposition of a variety of habitat types to meet the annual requirements of various life history stages (Merrell 1977, Pope et al. 2000). For example, the leopard frog requires three distinct habitats to complete its life cycle: a breeding pond, midsummer foraging habitat and a stream or other suitable water body for overwintering. The loss of any one of these critical habitats or the impairment of movement between habitat types could result in the demise of an entire local population. Relative to many other amphibians, this requirement for a seasonal mosaic of habitat types makes northern leopard frogs particularly vulnerable to the alteration and fragmentation of critical habitats on the landscape.

On a regional basis, many amphibian populations exist as metapopulations, represented by a set of linked but geographically discrete local populations occupying suitable habitats (Blaustein et al. 1994, Gulve 1994, Marsh and Trenham 2001). The size of local populations will fluctuate because of environmental factors, and natural stochastic mechanisms and local extinction may occur. But regionally, populations will be maintained through dispersal of individuals between populations and recolonization of vacant habitat. However, habitat fragmentation, and in extreme cases habitat loss, can result in populations becoming isolated or separated by greater distances. This separation can limit immigration from neighbouring populations, which can lead to a decrease in the fitness of individuals in the isolated population because of reduced gene flow and increase the likelihood that the isolated population will become extinct because of random population fluctuations (Blaustein et al. 1994, Corn 1994).

4. Habitat Loss. - Habitat loss is believed to be one of the causes of northern leopard frog declines in Washington, Oregon, Idaho and Montana (Koch et al. 1996). In Dickinson County, Iowa, habitat loss has caused populations to decline by two to three orders of magnitude over the last 70 years (Lannoo et al. 1994). Over the last half of this century, wetland drainage has been extensive in southern Alberta. From 1989 to 1999, approximately 75% to 93% of the wetland margins and approximately 18% to 42% of the wetland basins in southern Alberta have been affected by agriculture (I. McFarlane, pers. comm.). The extent to which wetland loss and alteration have affected northern leopard frog populations in the province is unknown, but in some areas population declines have undoubtedly been substantial as a result of it.

5. Livestock Activity. - In California, Jennings (1988) considered alterations to riparian vegetation by livestock grazing to be an important factor in the decline of ranid frog species. Livestock have been present at a number of sites in southern Alberta where leopard frogs have been found (Seburn 1992a, Kendell 2002b), and livestock disturbance is considered a threat to frog populations (Wershler 1991b). Intensive livestock activity can result in the following disturbances to riparian habitats: (1) grazing and trampling can reduce vegetation cover and diversity, and create drier soil conditions, reducing the quality of summer habitats; (2) cattle trampling along the shore and in the water can increase water turbidity and erosion, which could have negative effects on

tadpole and egg development; and (3) overwintering ponds contaminated by livestock feces and urine could result in increased nutrient levels and increased likelihood of anoxic conditions leading to winterkill. In addition, cattle movements along the shoreline and in the wetlands could potentially dislodge or trample egg masses, harming egg development and causing direct mortality.

It should be noted that the presence of ungulates and grazers may have some benefit for leopard frog habitat, in situations where water quality and breeding habitat are not compromised. For example, in British Columbia, non-native reed canary grass (*Phalaris arundinacea*) occurs in many areas of the Creston Valley Wildlife Management Area and has overgrown and displaced native vegetation, forming large monocultures along certain watercourses used by leopard frogs (D. Adama, pers. comm.). These dense patches of reed canary grass negatively affect frog movement and foraging (Waye and Cooper 2001). Local native ungulates have had a positive impact on the reduction of this invasive species in some areas (D. Adama, pers. comm.), and the potential use of cattle, under careful management, may be an option to improve upland habitat used as summer range and seasonal movements of leopard frogs.

6. Road Kills. - In Minnesota and Ontario, road kills account for the death of a large number of northern leopard frogs, particularly in the spring and fall when frogs are moving between overwintering and breeding sites (Ashley and Robinson 1996, Merrell 1977). In 1994, Yaremko (1994) reported the death of a small number of frogs along a frequently travelled trail in a meadow adjacent to the upper marsh at Sexton Creek. Overall, road kill is not believed to be a significant limiting factor of leopard frog populations in Alberta.

7. Water Management. - Wershler (1991a) noted that a number of water management practices could negatively affect northern leopard frogs in Alberta. The raising and stabilization of water levels to enhance recreational activities or to improve habitat for other species, such as fish or waterfowl, can lower the habitat potential for frogs by reducing the amount of wetland vegetation. Drawdowns of wetlands for vegetation management can affect tadpoles if the drawdown occurs before metamorphosis is complete, usually in late August. Similarly, flooding of artificial wetlands in the spring could dislodge eggs. Wershler (1991a) also indicated that on-stream dams alter physical processes along rivers. This could limit the creation of side channels and oxbows, which are important habitats for frogs. On-stream dams can also reduce winter streamflow levels, which could increase overwintering mortality by changing important water quality parameters such as temperature and dissolved oxygen levels.

Seburn (1993) raised concerns that the destruction of beaver dams could reduce available leopard frog habitat in the Cypress Hills of Alberta.

8. Harvest. - Throughout its range, the northern leopard frog has been collected for teaching and research needs, bait and even food (Gibbs et al. 1971, Koonz 1992, Wershler 1991a). In Alberta, commercial harvest has long been illegal, so the extent of collecting has probably been limited to the capture of frogs for fish bait and to the collecting and raising of tadpoles and frogs by children. In the past, these were probably relatively benign activities, but with the recent population declines, any loss must be considered unacceptable. The collecting of frogs by children has been noted in Medicine Hat and at Writing-on-Stone Provincial Park (Wershler 1991a).

With the designation of the northern leopard frog as a Threatened species under Alberta's *Wildlife Act* (see Status Designations section), it is illegal to collect the species for any purposes, unless a research permit or collection licence is obtained from Alberta Sustainable Resource

Development. With this designation, ongoing efforts are necessary to inform the public that collecting could be detrimental to frog populations.

9. Introduction of Game Fish and Exotic Species. - In many parts of western North America, declines of amphibian populations have been linked to the introduction of game and other species of fish (Corn 1994, Corn and Peterson 1996). In general, fish introductions are also thought to pose a threat to northern leopard frogs. The species is believed to avoid fish-bearing water bodies for spawning, as many fish species are known to prey on tadpoles and other age classes. Game fish are also known to prey on overwintering frogs (Emery et al. 1972).

The extent to which sport fish introductions have affected leopard frog populations in the province is unknown, but the matter is a cause for concern. In addition to direct mortality, little is known about the potential indirect effects of introduced species of fish on native amphibians. For example, evidence suggests that introduced hatchery-reared rainbow trout (*Oncorhynchus mykiss*) may serve as a vector for the spread of pathogens, such as *Saprolegnia ferax*, that have been associated with embryonic mortality of amphibians in the Cascade Mountains of Oregon (Kiesecker et al. 2001b) and elsewhere.

The introduction of bullfrogs (*Rana catesbeiana*) has also been implicated in the decline of northern leopard frog populations (Hammerson 1992, Koch et al. 1996, Lannoo et al. 1994, Panik and Barrett 1994, Schwalbe and Rosen 1988, Wiese 1990). Bullfrogs have not been introduced into Alberta. However, bullfrogs have been introduced into western Montana, which coincidentally is where the greatest leopard frog declines have been noted (Reichel and Flath 1995). Whether bullfrogs have played a role in the decline is unknown. It is also unknown whether the species will expand its range into this province, but the potential impacts on amphibian populations, and on biodiversity in general, is cause for concern.

Finally, in the White Mountains of Arizona, frog population declines have also been linked to the introduction of crayfish (*Orconectes virilis*, Fernandez and Bagnara 1995).

10. Contaminants and Wetland Acidification. - Because of their use of subcutaneous respiration, use of water for egg laying, reliance on both terrestrial and aquatic environments, and the different positions of larvae and adults in the food chain, amphibians are particularly vulnerable to a variety of contaminants, including pesticides (Bishop 1992, Harfenist et al. 1989). There is, however, no evidence linking northern leopard frog declines in Alberta to use of pesticides or other toxic compounds.

The herbicide Atrazine™, a widely used weedkiller in North America, has been implicated in the impaired sexual development of some frog species exposed to the chemical, essentially causing male frogs to grow female sex organs and hindering the calling ability of males (Hayes et al. 2002). However, Wesley and Karasov (2000) found no significant effect on development and metamorphosis of northern leopard frog larvae when treated with Atrazine™ in the laboratory, and it did not appear to pose a threat to the larvae through direct toxicity. The extent of herbicide use in Alberta and its potential effects on amphibians is unclear and requires greater attention.

Widespread reports of malformed amphibians in North America, particularly in the western United States, has prompted investigations into the cause(s) of the deformities. In Alberta, few records of malformed frogs have been submitted to Alberta Sustainable Resource Development. Researchers have found that some deformities in western toads (*Bufo boreas*) may be the result of a trematode known as *Ribeiroia ondatrae* (Johnson et al. 2001). The parasite is carried by snails and depends on snails as an essential link in its lifecycle. Runoff of nitrogen-based fertilizers and cattle manure into ponds increases the population of algae that the snails feed on,

thereby increasing the snail population, resulting in more parasites. Pesticides have also been suspected to cause deformities; however, little correlation between pesticides and presence or levels of malformations has been found (Johnson et al. 2002).

Concerns have been raised that acid rain could lower the pH of wetlands causing population declines in many species of amphibians in Canada (Clark 1992). Acid deposition is of greatest concern in the Canadian Shield region of eastern Canada. However, there have been no data linking population declines to increased habitat acidity (Clark 1992, Corn 1994). Acid deposition is of less concern in western North America, and episodic acidification has been dismissed as a cause of northern leopard frog declines in montane areas in Colorado (Corn et al. 1989).

11. Summary. - The cause of northern leopard frog population declines in Alberta is unknown. Initial population declines went largely unnoticed and in many areas were so complete that there was little or no opportunity to examine the reason(s) for the decline. Although little studied, population declines in Alberta do not appear to be part of a regular cycle. Instead, the declines appear to be related to a single, widespread factor affecting the survival of the species (Cottonwood Consultants 1986, Koonz 1992, Powell and Russell 1996, Roberts 1981, 1987, 1992, 1994, Vial and Saylor 1993).

The abrupt population declines observed in Alberta appear to follow a similar pattern of abrupt and massive population die-offs witnessed over much of the species' range in the upper midwestern states and the other prairie provinces during the 1970s. Despite investigations into these declines, the underlying cause(s) remain a mystery.

STATUS DESIGNATIONS*

1. Alberta. - In 1984, the northern leopard frog was identified as a "declining" species in Alberta, and the goals of monitoring population status and ensuring viable populations were established (Alberta Fish and Wildlife 1984). In the following year, the species was categorized as "Status Undetermined" in *A Draft Policy for the Management of Threatened Wildlife in Alberta* (Alberta Fish and Wildlife 1985). Cottonwood Consultants (1986) recommended that the species be regarded as "Threatened" in Alberta. Roberts (1987, 1991) suggested that the northern leopard frog was endangered, requiring management to prevent further declines and to aid in recovery. Because of concerns over widespread population declines in southern Alberta, the official status was upgraded in 1991 and the northern leopard frog was designated as a Red List species (Alberta Fish and Wildlife 1991a). This status was reaffirmed in 1996 (Alberta Wildlife Management Division 1996), and again in 2000 ("At Risk") in *The General Status of Alberta Wild Species 2000* (Alberta Sustainable Resource Development 2001).

A draft provincial management plan was prepared in 1992 (Seburn 1992c). This management plan established the goal of maintaining or restoring "a minimum of 30 viable subpopulations in six drainage systems across the historical range in Alberta," and also recommended that the northern leopard frog be designated as a Threatened species under Alberta's *Wildlife Act*. In January 1997, the species was designated as Threatened under the *Wildlife Act*.

2. Other Areas. - In British Columbia, the northern leopard frog was regarded as a "Blue List" species in 1991, a designation given to taxa

* See Appendix 1 for definitions of the status designations referred to in this section.

considered to be vulnerable to extirpation (Seburn 1992c, Waye and Cooper 2001). Since then, the leopard frog has been upgraded to the "Red List" and is designated as Endangered under British Columbia's *Wildlife Act* (Waye and Cooper 2001). No formal ranking system exists in Saskatchewan and leopard frogs are not afforded any legislative protection (Seburn and Seburn 1998). However, restrictions are in place to prevent human development in breeding areas (W. Harris, pers. comm.). In Manitoba, a permit is required for commercial collecting of leopard frogs (Preston 1987). The northern leopard frog was identified as a "species of concern" in the *Prairie Conservation Action Plan* (World Wildlife Fund Canada 1988).

In 1998, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) listed the prairie population of the northern leopard frog as "Special Concern" (COSEWIC 2002), based on the status report prepared by Seburn and Seburn (1998). The designation reflected the continuing presence of potential causes of the decline in many jurisdictions, and the lack of recolonization by the species.

The Nature Conservancy and the Natural Heritage Network rank the northern leopard frog as G5 (global rank), N5 in Canada, and N5 the United States (NatureServe Explorer 2002). In adjacent jurisdictions, it is considered S1 in BC, S4 in Saskatchewan and Manitoba, and S3S4 in Montana (NatureServe Explorer 2002). Ranks in other Canadian jurisdictions are mostly S? or S5, whereas ranks in other U.S. jurisdictions are variable, ranging from S1 to S5 (NatureServe Explorer 2002).

The northern leopard frog has been placed on a candidate list of species of special concern by the State of Colorado (Livo 1986).

RECENT MANAGEMENT IN ALBERTA

1. Planning. - The planning of management activities for northern leopard frogs has been guided by the preparation of a provincial status report (Wagner 1997) and a draft management plan (Seburn 1992b). The draft provincial management plan (Seburn 1992b) outlined objectives for population monitoring and habitat management, and for educating the public about the plight and conservation of the leopard frog in Alberta. The report also discussed the possible need to re-establish populations by transplanting individuals from existing populations to areas containing suitable habitat.

The species was also considered as part of planning exercises conducted by the North American Waterfowl Management Plan (NAWMP) in Alberta. It was ranked as a priority vertebrate species for NAWMP program delivery in the prairie and aspen parkland biomes (Patriquin 1993).

2. Population Monitoring. - The Alberta Fish and Wildlife Division launched a poster campaign in 1989, which asked the general public to report all sightings of northern leopard frogs. Over 150 reports were received in response to the campaign (Seburn 1992a, D. Seburn 1994, Wershler 1991a). Many of these reports turned out to be other species, or were thought to be unreliable observations (Wershler 1991a). Nevertheless, many of the reports led to the discovery of new population centres, proving the value of the program.

During 1990 and 1991, field surveys were conducted to update and expand the information base on leopard frog habitats, populations and distribution in southern Alberta. Sightings reported during the poster campaign were also checked during the field program. All data were entered into BSOD.

In 1994, the Alberta Amphibian Monitoring Program (AAMP) was initiated (Alberta Fish and Wildlife 1994, Powell and Russell 1996, Yaremko 1996). This program was implemented under the auspices of the Declining Amphibian Population Task Force established by the Species Survival Commission of the

World Conservation Union. In 1997, the program became provincial in scope, collecting information on all amphibian species in Alberta (Takats 2002a, 2002b). The monitoring program was designed to gather basic presence and phenology data on amphibians using volunteers, and to increase public awareness of, and interest in, amphibians. Volunteers are provided with a monitoring manual that contains information on the identification and ecology of Alberta's amphibians (Alberta Sustainable Resource Development and Alberta Conservation Association 2001), as well as monitoring instructions and simple data sheets. Also included is a cassette tape that features the calls of the frogs and toads in Alberta, to assist with identification. In addition, volunteers in the program receive a biannual newsletter called "Croaks and Trills" to encourage yearly participation and submission of data. The newsletter also provides a means to highlight yearly program results and communicate amphibian-related information and projects. To date, approximately 600 individuals have become involved with the program and hundreds more are reached each year through the general promotion of the program. Data obtained by the volunteers are entered into BSOD.

3. Habitat Securement, Protection and Enhancement. - In 1991, a management plan was developed for the Prince's Spring area, which contains a major breeding population of northern leopard frogs (Wershler 1991b). The plan outlined the need for fencing around spring-fed streams to protect fragile riparian habitats from cattle damage. The springs had already been fenced prior to 1980 (Hofman 1992). Revisions to the fencing plan were made (Wershler 1992b) and fences were subsequently established to include the streams in 1992 (Hofman 1992).

High quality leopard frog habitat exists at Sexton Creek in the Cypress Hills, and is located within the proposed Eagle's Nest Ranch Natural Area (Biota Consultants 1992). Management considerations for the proposed natural area include restricting livestock activity around wetlands to protect northern leopard frog habitat (Biota Consultants 1992). Apart from public awareness talks given to staff and visitors of the natural area through the RANA project, no current management protection has been afforded to the area to date.

In the fall of 1994, a population of northern leopard frogs was discovered along a small creek extending from Lonesome Lake to the Bow River near Bow City (D. Watson, pers. comm.). Portions of the creek are dominated by small spring-fed wetlands, which may provide important breeding or overwintering habitat. Most of the creek flows across the Circle E project, which is being developed for waterfowl production under the NAWMP. Project development began in 1995 and management plans for the project recognized the importance of the creek as leopard frog habitat. In 1996, cross fencing was erected across pastures bordering portions of the creek to prevent disturbance of the wetlands by cattle during the breeding season (A. Balaski, pers. comm.). To further protect two important breeding ponds along the drain throughout the year, a proposal was drafted in 2002 to fence off these sites (Kendell 2002d). The proposal recommended that the two ponds be completely fenced to exclude cattle activity. Implementation of the proposed action is planned for the near future.

4. Research. - In addition to the previously discussed survey and monitoring programs, three research projects with applications for leopard frog management were conducted prior to 1997. Seburn (1993) examined the feasibility of using pond enclosures to assess growth rates of transplant and control populations of tadpoles. However, the methodology was found to be inadequate because of high predation rates and low growth rates within the enclosures. In 1993, habitat use and YOY dispersal studies were conducted at Sexton Creek (Seburn 1994, Seburn et al. 1997). The YOY dispersal and

overwintering survivorship were also studied at Sexton Creek in 1994 (Yaremko 1994).

Since 1997, several more research studies have been conducted, leading to, and in support of, a northern leopard frog reintroduction project (see Subsection 5. Reintroduction of the Northern Leopard Frog). The initial phase of the project involved an examination and literature review of the feasibility of translocating leopard frogs. Important candidate sites for release and source populations to draw egg masses from were investigated and identified (Fisher 1999).

A study by Wendlandt (1999) investigated habitat preferences of the northern leopard frog and environmental conditions before and at the initiation of hibernation. Under this radiotelemetry study, five leopard frogs were fitted with radio transmitters and tracked to potential hibernacula, at two sites in the Cypress Hills, in southern Alberta.

Butterworth (1999) investigated the potential impact of diseases on the re-establishment of amphibians and the role of disease in amphibian declines. Butterworth (1999) also examined a protocol for the reintroduction of amphibians in order to prevent the introduction of diseases at sites of relocation. The impacts of amphibian diseases on relocation programs in North America were also examined.

Winter physiology and ecological requirements of the northern leopard frog were studied in the area surrounding the Raven Brood Trout Station (the proposed site for a pilot reintroduction program) in 1999 (Kendell 2000a). The study involved radio tracking translocated adult leopard frogs to overwintering locations to better understand habitat use and frog behavior before and during hibernation.

A study examining aquatic overwintering conditions for leopard frogs was undertaken in 2000 near Brooks, Alberta (Kendell 2000b). The purpose of the study was to collect a variety of ecological data on the aquatic conditions necessary for leopard frog hibernation. A number of water quality parameter tests were conducted at a variety of sites where leopard frogs were present, or extirpated, and at sites where they could potentially occur.

5. Reintroduction of the Northern Leopard Frog. - The recovery and re-establishment of northern leopard frog populations over much of their former range in southern Alberta will be largely dependent on the dispersal of individuals from existing populations. However, it is possible that the relative isolation of some populations may limit opportunities for population expansion because of the inability of individuals to disperse to other areas (Roberts 1994). Furthermore, some areas of suitable habitat may now be unavailable for recolonization because of habitat alterations (i.e., development, agricultural activities and drought) that have eliminated dispersal corridors. This isolation may be particularly true of large areas in the Parkland, which are separated from the remaining breeding populations in the south by large expanses of dry upland habitat (Roberts 1994). As a result, it was suggested that the re-establishment of the northern leopard frogs in many parts of their former range may therefore be dependent on transplanting individuals from major breeding populations in southern Alberta (Cottonwood Consultants 1986, Roberts 1987, 1991, 1992, 1994, Seburn 1992c, Wershler 1991a, Fisher 1999). Furthermore, the northern leopard frog exhibits many of the requirements proposed in conservation literature for successful translocations (Fisher 1999). Such conservation-oriented programs have proven to be valuable tools for the conservation of endangered amphibian species (Conant 1988, Denton et al. 1997, Fisher 1999, Sarrazin and Legendre 2000).

Under an informal pilot reintroduction program, northern leopard frogs were released at two sites in central Alberta (Roberts 1991, 1992). At both sites, frogs survived and reproduced for several years following release (W. Roberts, pers.

comm.). However, at one of the sites a winterkill event eliminated the population. At the other site, in the upper North Saskatchewan River basin, the population continues to persist and is monitored annually (W. Roberts, pers. comm.).

In 1998, the Fish and Wildlife Division began to explore the feasibility of reintroducing leopard frogs into formerly occupied habitats. In 1999, a formal pilot reintroduction project was initiated at the Raven Brood Trout Station near Caroline, Alberta (Kendell 2001, 2002c, Wendlandt and Takats 1999). The primary goal of the project is to re-establish leopard frogs in the upper Red Deer and North Saskatchewan river drainages. The project involves the captive rearing of leopard frogs from the egg stage of development to metamorphosed frog in two large outdoor ponds at the station.

The controlled release of leopard frogs reared at the Raven Brood Trout Station occurred at three sites from 1999 to 2002. The Raven River near Caroline, Alberta was selected as the pilot release site for the project in 1999. A second release site was chosen in 2001 near Rocky Mountain House, Alberta and is called the North Saskatchewan River release site. In 2002, captive-reared frogs were also released at a third release site, a Ducks Unlimited project near Red Deer, Alberta. To date, a total of nearly 10 000 young, captive-reared, leopard frogs have been released into these designated sites. A major objective of the project is to release frogs over multiple years to ensure the establishment of a variety of age classes of frogs that may be necessary to achieve a self-sustaining, viable population. In addition, surveys are conducted at each release site for frogs released the previous year(s).

Initial evidence suggests that the reintroduction efforts at the first release site have been a success. In 2001, at least 10 leopard frogs released in previous years were located within the Raven River release study area, representing the first re-occurrence of the species in that area in nearly 50 years. Within the same study area, at least three leopard frogs were heard calling from a pond in the spring of 2002 and one leopard frog egg mass was discovered. In addition, several leopard frogs were observed throughout the summer at the Raven River release site in 2002.

Surveys conducted in 2002 by biologists at the North Saskatchewan release site failed to produce any observations of frogs released in 2001. However, interviews with local land users at the site resulted in two unconfirmed leopard frog reports in 2002, before the second release of frogs occurred.

In 2001, the Calgary Zoo was approached to explore the feasibility of expanding the reintroduction program to include a captive-breeding program. Objectives of the proposal included developing non-invasive techniques for breeding leopard frogs in captivity, husbandry practices, producing various age classes of frogs for reintroduction, increasing public awareness of the challenges facing amphibians, and conducting scientific studies benefiting the northern leopard frog in captivity and in the wild (Dalgleish 2001). To date, no further developments on this proposal have been undertaken.

Two additional reintroduction projects have recently been undertaken. The first project is in British Columbia (Waye and Cooper 2001, Wind 2002) and the second is in Montana (U.S. Department of the Interior 2002, J. Lichtenberg, pers. comm.).

There are a number of genetic concerns that should be addressed as part of any species conservation program. The minimum viable population size of amphibian populations may be an important consideration in reintroduction strategies (Andren and Nilson 1995, Dodd and Seigel 1991). The minimum size of a viable population will depend on landscape or habitat features that affect the dispersal ability and the

movement of frogs among spatially subdivided populations, thereby enhancing or discouraging gene flow. The minimum viable population size of the northern leopard frog in Alberta is not known and requires further investigation, as part of Alberta's leopard frog reintroduction program.

Other critical elements for consideration as part of species conservation programs include the harmful effects of loss of genetic variation as a result of inbreeding and the random loss of genes in small populations from genetic drift (Dodd and Seigel 1991, Driscoll 1998). The possible consequence of the small size of the leopard frog populations at release sites and existing natural sites remains unclear. It may be difficult to predict the importance of loss of genetic variation for the leopard frog and the long-term survival of the species at existing natural sites and release sites. Further investigation is required to assess these genetic concerns.

6. Public Information and Education. - Public information programs are important for building awareness about the leopard frog, as well as for soliciting sighting and other information from the public, for requesting assistance in protecting and maintaining habitat, and for reducing activities, such as collecting, that may be detrimental to frog populations.

In Alberta, the dissemination of public information about the leopard frog has included a poster campaign soliciting sightings, which was initiated in 1989, and the publication of a brochure in 1991 (Alberta Fish and Wildlife 1991b) and reprinted in 1998 (Alberta Fish and Wildlife Division 1998). The northern leopard frog reintroduction project, AAMP and RANA have also extensively profiled this species through public talks, meetings, the media and volunteer involvement. Finally, an elementary school teacher's guide (targeted for K 1-3 curriculum) featuring the northern leopard frog was published in 1997 (Alberta Environmental Protection 1997).

Information about amphibians in general has been made available through an amphibian monitoring program teacher's guide (targeted for grade 5 and 6 curriculum) (Alberta Conservation Association and Alberta Environment 1999). As well, a poster entitled *Amphibians of Alberta* was also produced in 1999, which featured the leopard frog along with the nine other species of amphibians found in the province.

SYNTHESIS

Before 1980, the northern leopard frog was widely distributed and locally abundant over much of Alberta south of Edmonton. However, populations are now greatly reduced in number, and the range is limited mainly to the lower reaches of the South Saskatchewan, Bow and Milk river drainage basins.

In Alberta, the cause(s) of the abrupt and widespread population declines that occurred in the late 1970s and early 1980s remains a mystery. Suggested causes include wetland drainage, drought, habitat degradation, cattle grazing, pesticide and herbicide use, game fish introductions and disease. A number of these limiting factors continue to negatively affect the species, and may lead to continuing population declines.

Recent increases in local populations in Saskatchewan (A. Didiuk, pers. comm., Seburn 1992b) and Manitoba (Koonz 1992) provide some hope that northern leopard frog populations may recover in Alberta. However, to date there has been no evidence of recolonization of broader areas with historical leopard frog occurrences. Large tracts of unsuitable habitat that separate existing populations may impede the natural recovery and re-establishment of populations in formerly occupied areas. The successful re-establishment of stable breeding populations of leopard frogs in formerly occupied areas may be reliant on the northern leopard frog reintroduction project.

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APPENDIX 1. Definitions of selected legal and protective designations.

A. The General Status of Alberta Wild Species 2000 (after Alberta Sustainable Resource Development 2001)

2000 Rank	1996 Rank	Definitions
At Risk	Red	Any species known to be "At Risk" after formal detailed status assessment and designation as "Endangered" or "Threatened" in Alberta.
May Be At Risk	Blue	Any species that may be at risk of extinction or extirpation, and is therefore a candidate for detailed risk assessment.
Sensitive	Yellow	Any species that is not at risk of extinction or extirpation but may require special attention or protection to prevent it from becoming at risk.
Secure	Green	Any species that is not "At Risk", "May Be At Risk", or "Sensitive".
Undetermined	Status Undetermined	Any species for which insufficient information, knowledge or data is available to reliably evaluate its general status.
Not Assessed	n/a	Any species known or believed to be present but which has not yet been evaluated.
Exotic/Alien	n/a	Any species that has been introduced as a result of human activities.
Extirpated/Extinct	n/a	Any species no longer thought to be present in Alberta ("Extirpated") or no longer believed to be present anywhere in the world ("Extinct").
Accidental/Vagrant	n/a	Any species occurring infrequently and unpredictably in Alberta, i.e., outside their usual range.

B. Alberta Wildlife Act/Regulation

Species designated as "Endangered" under Alberta's *Wildlife Act* include those listed as "Endangered" or "Threatened" in the Wildlife Regulation.

Endangered	A species facing imminent extirpation or extinction.
Threatened	A species that is likely to become endangered if limiting factors are not reversed.

C. Committee on the Status of Endangered Wildlife in Canada (after COSEWIC 2002)

Extinct	A species that no longer exists.
Extirpated	A species that no longer exists in the wild in Canada, but occurs elsewhere.
Endangered	A species facing imminent extirpation or extinction.
Threatened	A species that is likely to become endangered if limiting factors are not reversed.
Special Concern	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Not at Risk	A species that has been evaluated and found to be not at risk.
Data Deficient	A species for which there is insufficient scientific information to support status designation.

APPENDIX 1 continued.

D. Heritage Status Ranks: Global (G), National (N), Sub-National (S) (after Alberta Natural Heritage Information Centre 2002)

G1/N1/S1	5 or fewer occurrences or only a few remaining individuals. May be especially vulnerable to extirpation because of some factor of its biology.
G2/N2/S2	6-20 or fewer occurrences or with many individuals in fewer locations. May be especially vulnerable to extirpation because of some factor of its biology.
G3/N3/S3	21-100 occurrences, may be rare and local throughout it's range, or in a restricted range (may be abundant in some locations). May be susceptible to extirpation because of large-scale disturbances.
G4/N4/S4	Typically >100 occurrences. Apparently secure.
G5/N5/S5	Typically >100 occurrences. Demonstrably secure.
GX/NX/SX	Believed to be extinct or extirpated, historical records only.
GH/NH/SH	Historically known, may be relocated in future.

E. United States Endangered Species Act (after National Research Council 1995)

Endangered	Any species which is in danger of extinction throughout all or a significant portion of its range.
Threatened	Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

APPENDIX 2. Known museum specimens of northern leopard frogs collected in Alberta. See Figure 1.

Catalogue #	Collection Location	Date
National Museum of Canada, Ottawa, ON		
NMC593(a)	Hilly Island Rapid, Rocher River, W end of Lake Athabasca	5 Aug 1914
NMC1111	Morin	8 Aug 1924
NMC2086	Cypress Hills	Not given
NMC3363	2.4 miles N of Waterton Lakes National Park	12 Jun 1957
NMC3364	9.6 miles S of Lethbridge	14 Jun 1957
NMC3366	2.3 miles NE of Cardston	14 Jun 1957
NMC3370	1.4 miles E of Mountain View	14 Jun 1957
NMC3380	Indian Creek at Highway #6, Waterton Lakes National Park	17 Jun 1957
NMC3383	Beaver ponds 7.9 miles S of junctions of Highways #5&#6, Waterton Lakes National Park	17 Jun 1957
NMC3418	4 miles N of Taber	26 Jun 1957
NMC3431	SW corner of Cypress Hills Prov. Park	2 Jul 1957
NMC5278	Kin Coulee, Medicine Hat	23 May 1961
NMC5488	1.7 miles N of Graburn	5 Jul 1961
NMC5502	Elkwater Lake	9 Jul 1961
NMC5503	31.6 miles N on Highway #48 of Wildhorse	9 Jul 1961
NMC5504, 5505	18.6 miles N on Highway #48 of Wildhorse	9 Jul 1961
NMC5507	10.6 miles W on Highway #1 of Elkwater Lake turnoff	10 Jul 1961
NMC5508	6.1 miles W on Highway #1 of Walsh turnoff	10 Jul 1961
NMC5509	4.3 miles W on Highway #1 of Walsh turnoff	10 Jul 1961
NMC5512	1.4 miles W on Highway #1 of Walsh turnoff	10 Jul 1961
NMC5526	4.3 miles W on Highway #1 of Walsh turnoff	12 Jul 1961
NMC5537	9 miles E on Highway #3 of Seven Persons	15 Jul 1961
NMC5539	3.5 miles E on Highway #3 of Seven Persons	15 Jul 1961
NMC5540	8.6 miles N of Orion	15 Jul 1961
NMC5542	17 miles NE of Manyberries	15 Jul 1961
NMC5544	24 miles NE of Manyberries	15 Jul 1961
NMC5545,5546	4.6 miles S of Highway #1 on Manyberries road, E side of Medicine Hat	15 Jul 1961
NMC5548	4.3 miles W on Highway #1 of Walsh	15 Jul 1961
NMC5552	4.3 miles W on Highway #1 of Walsh	18 Jul 1961
NMC6024	0.5 miles NW on Highway #1 of Brooks turnoff	20 May 1962
NMC7138	1.5 miles N of Rocky Mountain House	9 Jun 1963
NMC7145	2.5 miles N of Rocky Mountain House	9 Jun 1963
NMC7151	5.8 miles N of Rocky Mountain House on Crimson Lake Rd.	10 Jun 1963
NMC7175	Fish Creek, near Priddis	13 Jun 1963

APPENDIX 2 continued:

NMC7177	5 miles NW of Priddis	13 Jun 1963
NMC7236	4.3 miles N of Highway #6 of Twin Butte	3 Jul 1963
NMC7238	1.1 miles N on Highway #6 of Twin Butte	3 Jul 1963
NMC7246	1 mile W of junctions of Highways #5&#6, Waterton Lakes National Park	4 Jul 1963
NMC7328	2.9 miles S on Highway #1 of Strathmore	26 Jul 1963
NMC7336	4.2 miles W on Highway #1 of Walsh	30 Jul 1963
NMC8642	16 miles E and 8 miles S of Milk River	21 Jul 1965
NMC9555	8 miles S of Pincher Creek, along Highway #6	13 Sep 1966
NMC9556	17 miles S of Calgary in Sheep River at Highway #2	13 Sep 1966
NMC9557	Knights Lake, Waterton Lakes National Park	17 Sep 1966
NMC9558	8 miles N of Big Chief Mountain Customs Station	17 Sep 1966
NMC9585	Milk River, 0.25 miles south	24 May 1966
NMC9586	17 miles W of Wildhorse (SE1/4-1-1-5-W4)	28 May 1996
NMC9588	Milk River, 8 miles E and 2.5 miles S	28 May 1966
NMC9590	Milk River, 15.5 miles W & 4.5 miles S of south fork of Milk River	29 May 1966
NMC9591	Milk River, 18 miles E, 4 miles S (SW33-1-25-W4) (Van Cleeve Coulee)	29 May 1966
NMC9592	Milk River, 8.0 miles E and 3.0 miles S (NW1-2-15-W4)	?
NMC9600	Milk River, 4 miles E and 3.5 miles S, Gold Springs Park	25 Jul 1966
NMC9603	18 miles S and 1 mile E of Elkwater (NE30-5-2-W4)	28 Jul 1966
NMC9604	Milk River, Lodge Creek, 18 miles S,1 mile E of Elkwater (NE30-5-2-W4)	28 Jul 1966
NMC9607	Red Creek 1.5 miles W, 10.5 miles S of Milk River town (SW5-1-16-W4)	10 Aug 1966
NMC9609	Halfbreed Creek, Aden, 8 miles due N and 1 mile due E	4 Sep 1966
NMC9892	Writing-on-Stone Prov. Park	26 Jun 1967
NMC10320	Calgary, SW bypass at rifle range and power transformer	15 May 1966
NMC10397	6.1 miles W of Stavely on Willow Creek Park road	18 June 1966
NMC10400	18.4 miles W of Stavely on Willow Creek Park road	18 June 1966
NMC10665	0.5 miles W of Whiskey Creek near junction with Fish Creek on Fish Creek road, SW of Priddis	21 Jul 1966
NMC10670	coulee, 15 miles S of Seven Persons	23 Jul 1966
NMC10754	1.9 miles S of Bragg Creek	17 Sep 1966
NMC10772(b)	17.1 miles S of Smoky River bridge on Highway #34	22 Jun 1965
NMC10773(b)	5.1 miles N of Valleyview on Highway #34	22 Jun 1965
NMC10777(b)	2.8 miles S of Little Smoky on Highway #34	23 Jun 1965
NMC10780(b)	10.7 miles S of Little Smoky	23 Jun 1965
NMC10784(b)	18.2 miles S of Whitecourt on Highway #34	24 June 1965
NMC10794	14.7 miles S of Muirhead	16 Jun 1966
NMC14234	18 miles E and 4 miles S of Milk River (3-1-13-W4)	3 Jun 1967

APPENDIX 2 continued:

NMC14244	18 miles E and 4 miles S of Milk River (SW33-1-13-W4)	10 Aug 1967
NMC14246	18 miles E and 4 miles S of Milk River (SW33-1-13-W4)	28 Aug 1967
NMC14652	Milk River, 1 mile E of Writing-on-Stone Prov. Park	31 May 1970
NMC16083	2 miles S of Grassy Lake	9 Jun 1973
Provincial Museum of Alberta, Edmonton, AB		
Z71.62.1	Hardisty Campsite, Battle River	10 Aug 1971
Z70.49.59	South Pinhorn Grazing Reserve	31 May 1970
Z68.80.13	Aden bridge over Milk River	10 Sep 1968
Z68.47.2	Lake Newell	11 Jun 1968
Z68.47.1	Lake Newell	11 Jun 1968
Royal Ontario Museum, Toronto, ON		
ROM7779	Lethbridge in irrigation ditch	1946
ROM7865,7866	Elkwater Lake	5 Jul 1948
ROM9320	Waterton Lakes National Park at park entrance	16 Jul 1955
ROM9397	Medicine Hat, Saskatchewan River and Creek NE of town	11 Jun 1920
Museum of Comparative Zoology, Harvard University, Cambridge, MA		
17550	Medicine Hat	?
Field Museum of Natural History, Chicago, IL		
39471	Medicine Hat	Jul 1929
56424-25	Elkwater Lake	5 Jul 1948
56426	Boschee Creek	4 Jul 1948
56427-28	Mitchell Creek	14 Jul 1948
56429-30	Willow Creek	6 Jul 1948
56426-32	Battle Creek and Vicinity	18 Jul 1948
Tongrass Historical Society Museum, Anchorage, AK (see Hodge 1976)		
55	Grand Forks	?
57,59	Milk River	?
University of Calgary Museum of Zoology, Calgary, AB		
1975.114	7.8 miles from Sundre	?
1975.115	Midnapore	?
1975.116-117	4-5 miles S of Elkwater, Cypress Hills Prov. Park	?
1975.118-120	Wildhorse	?
1975.290-292	Hays	?
1977.66	Nose Creek	?
	Wildhorse	16 May 1963
	4.5 miles S of Elkwater, Cypress Hills Prov. Park	22 May 1962
	Nose Creek (Calgary), just W of Edmonton Trail	7 Jul 1962

APPENDIX 2 continued:

	Nose Creek, N of Airport Road, Calgary	28 Jul 1962
	Big Hill Creek, 2.2 miles NE of Cochrane	28 Jul 1962
	7.8 miles S of Sundre, Fallen Timber Creek	24 Jun 1964
University of Alberta Museum of Zoology, Edmonton, AB		
2,5, 6-11,13	Elkwater Lake, Cypress Hills	5 Jul 1948
14,15	Cardston	15 Aug 1949
16	Eagle Lake, near Strathmore	15 Jun 1949
126	Drumheller	11 May 1950
127	Drumheller	18 May 1950
135	Drumheller	5 Jun 1950
141,142	Beynon	5 Jul 1950
222	Milk River	9 Jul 1950
262	Milk River	1 Aug 1950
266	Spring Creek R.S. Cypress Hills	1 May 1950
270-272	Tilley	16 Aug 1950
305,306	Gros Ventre Creek Cypress Hills	20 Aug 1950
319	Cardston	29 Aug 1950
355-357	Eagle Butte	5 Aug 1951
358	St. Kilda	14 Aug 1951
359	Medicine Hat	14 July 1951
361	Brooks	8 Jul 1951
362-364	High River	25 Aug 1951
365,366	Calgary	18 Aug 1951
367	Gleichen	3 Aug 1951
368	Edmonton	5 Oct 1951
369,370	Lethbridge	23 Jul 1951
371	Crammond	25 May 1951
372	Burmis Lake	24 Jun 1951
391	Macleod	18 Aug 1951
404	Vauxhall	Aug 1951
408	Whiskey Gap	21 Jul 1951
475	Cardston	21 Jul 1951
476	Taber	19 Jul 1951
477	Vauxhall	19 Jul 1951
478	Taylorville	21 Jul 1951
585-588	Onefour	1951
719	Raven River Fish Ponds	11 Aug 1951

APPENDIX 2 continued:

721	Onefour	Fall 1953
767	Redcliff	5 Aug 1955
768,769	Picture Butte	19 May 1956
1238-1241	Hussar	16 Dec 1953
1242-1253	Calgary	18 Aug 1951
1254-1257	6 miles S of Caroline	15 Aug 1954
1258	High River	8 Aug 1952
1382	Raven Fish Pond	11 Aug 1955
1383	Milk River near Milk River town	23 Aug 1950
1428,1430,1431	Milk River 19 miles W of Wildhorse	3 Jun 1962
1429	Milk River 19 miles W of Wildhorse	5 Jun 1962
1432	Milk River 19 miles W of Wildhorse	18 May 1961
1433-1437	Milk River 19 miles W of Wildhorse	19 May 1961
1547	Ross Creek	3 Aug 1966
1664-1680	Middle Coulee, 5 miles S of New Dayton	6 Jun 1968
1740-1742	Road to Eagle Butte, Cypress Hills	2 Jun 1968
1743-1744	Highway 48 approximately 25 miles S of Cypress Hills	9 Jun 1968
1745-1752	Highway 48 approximately 26 miles S of Cypress Hills	9 Jun 1968
1753	Eagle Butte, Cypress Hills	12 Jun 1968
1754-1755	Stream connected with Little Fish Lake	5 Jul 1968
1756	Highway 36 just S of Crossford Junction	6 Jul 1968
1757-1766	Dinosaur Park	7 Jul 1968
1767-1771	Road to Thelma, Cypress Hills	10 Jul 1968
1772-1774	Graburn Gap Road, past campsite, Cypress Hills	11 Jul 1968
1775,1776	Road to Graburn Gap, just in evergreens, Cypress Hills	11 Jul 1968
1777	Lost River by One-Four	13 Jul 1968
1861	Highway 48, second bridge, 25 miles S of Cypress Hills	9 Jun 1968
1862	Stream east end of Little Fish Lake	5 Jul 1968
1863-1865	Highway 48, second bridge, 25 miles S of Cypress Hills	9 Jun 1968
1926-1938	Pond near Tyrell Lake	1 Sep 1969
1983, 1984	Lake Newell, 12 miles S and 3 miles W of Brooks	22 Jun 1970
2017, 2018	Cottonwood Creek, 9 miles N of Waterton, Waterton Lakes National Park	30 Jul 1971
2028	Lake Newell	8 Jun 1972
2076-2078	Lake Newell	14 Jun 1972
2122-2124	Pinhorn Grazing Reserve 49°04'N; 110°57'W	28 Aug 1972
2191	Lodge Creek below Saskatchewan Reservoir (in Alberta)	15 May 1973
2217	Sage Creek, 7 miles S of Cressday	17 July 1975

APPENDIX 2 continued:

2268-2271	1/2 mile E of Heatherdown	16 May 1976
2439	Spruce Coulee, Cypress Hills Prov. Park	3 Aug 1976
2449	Spring tributary of Clearwater River 1/4 mile N of Ricinus	12 Dec 1976
2450	Spring tributary of Clearwater River 1/4 mile N of Ricinus	7 Nov 1976
2472	1/2 mile E of Heatherdown	26 Apr 1977
2482-2484	1/2 mile S of Heatherdown	7 May 1977
2557	Red Deer River	16 Jul 1975
2562	S end of Lake Newell	4 Jun 1979
2563	North Milk River tributary, 18 miles E of Del Bonito	5 Jun 1979
2651	Pinepound Creek, 1 mile W of Spring Coulee	3 May 1980
2654	8 miles SE of Rolling Hills	29 Jun 1980
2882	Lodge Creek	Jun 1976

(a) The wrong site location is probably given for this specimen (NMC593). The specimen probably refers to a collection at the Natla Rapids on the Talston River, Northwest Territories on 5 August 1914 (Harper 1931a)

(b) Tadpoles can be difficult to identify to species. Until further confirmation, these records must be considered suspect (F. Cook, pers. comm.).

APPENDIX 3. Pre-1981 observational records of northern leopard frogs in Alberta. Natural regions follow Achuff and Wallis (1977). See Figure 1.

Location	Source	Comments
Foothills Grassland Natural Region		
Hillspring	Wershler (1991a)	S of Hillspring in the vicinity of the Belly River
Whiskey Gap	Wershler (1991a)	N fork of the Milk River near Whiskey Gap
Fort McLeod	C. Wallis (pers. obs.)	Observed in 1978
Willow Creek	Crack and Danielson (1974a)	Willow Creek at Willow Creek Prov. Park
Foothills Parkland Natural Region		
Outpost Lake	Wershler (1991a)	Police Outpost Prov. Park
Paine Lake-Beaverdam Lake	C. Wallis (pers. obs.)	Beaverdam Lake, creek SE of Paine Lake, and wetlands along Lee Creek SE of Paine Lake. Observed 20 June 1978.
Waterton Lakes National Park	C. Wershler and C. Wallis (pers. obs.)	One calling at pond at N gate of Waterton Lakes National Park on 28 April 1977
Foothills Creek	C. Wallis (pers. obs.)	Foothills Creek, E of Pecten, observed in 1977
Foothills Parkland and Northern Fescue Grassland Natural Regions		
Beaverdam Flats	Bird (1974), Pinel (1980)	"Present in the lagoon and some old gravel pits"
Beddington Creek, Calgary	Bird (1974)	"This frog is quite abundant in the beaver ponds, and was seen from May through August"
Bowmont Flats	Pinel (1980)	"Occasional in the gravel pit area"
Cominco, Calgary	Bird (1974), Pinel (1980)	"Abundant in the lagoon area"
Edworthy Park, Calgary	Pinel (1980)	"Occasional in the ponds and sloughs"
Fish Creek Prov. Park, Calgary	Bird (1974), Pinel (1980), Wershler (1991a)	"Frequent along the creek banks"
Glenmore Park, Calgary	Bird (1973), Pinel (1980)	"The most abundant frog in the beaver and oxbow ponds." Breeding noted
Inglewood Bird Sanctuary, Calgary	Pinel (1980), Wershler (1991a)	"Fairly common in the pond and extreme north end of the water channel in the early 1960s. Now it is almost non-existent for unknown reasons"
Sandy Beach, Calgary	Pinel (1980)	"Occasional sightings in the pond below the dam. It is heard in late April"
Cochrane	Bird (1975b)	
Rocky Mountain - Montane Natural Region		
Beauvais Lake Prov. Park	Crack and Danielson (1974b), Spalding (1980, pg.70)	"Observed along the lakeshore and in the ponds and streams during the summer"
Burmis	Wershler (1991a)	"In the vicinity of Burmis"
Chain Lakes Prov. Park	Crack and Danielson (1974c)	"Seen along the lakeshore and marsh below dam"
Bow Valley Prov. Park	Salt (1977, 1979)	
Yamnuska Centre	Salt (1977, 1979)	
Shepard Creek	C. Wallis (pers. obs.)	Seen in 1977 in bullrush pond on the upland

APPENDIX 3 continued:

Foothills Grassland and Rocky Mountain - Montane Natural Regions (Disjunct)		
Cypress Hills	Wershler (1991a), Halladay (1965), Lewin (1963)	Reservoirs, creeks and ponds in the Cypress Hills
Mixed Grassland Natural Region		
Milk River - Writing-on-Stone	Wershler (1980)	Milk River and associated coulee streams in the vicinity of Writing-on-Stone Prov. Park. "Breeds locally along deep, calm stretches of Police and Van Cleeve Creeks, especially in beaver ponds"
Lower Milk River	Wallis (1976)	Milk River Canyon, associated coulee streams, and upland ponds in the vicinity of the lower Milk River. "Common along creeks and river valley, where water is permanent"
Lost River - Canal Creek	C. Wershler (pers obs.)	Observed along the Lost River, Canal Creek and adjacent upland ponds in the 1970s
Wildhorse	Wershler (1991a)	Wildhorse Lake area
Manyberries	C. Wershler (pers. obs.)	Manyberries Creek drainage near Manyberries and S of Manyberries in the early 1970s. Also in ponds N of the Onefour Experimental Station
McNab	Wershler (1991a)	NE of McNab in Tyrrell Lake area
Lethbridge	Lethbridge Naturalists' Society (1978), Moore and Strickland (1954)	Within the city of Lethbridge
Picture Butte	Wershler (1991a)	Just W of Picture Butte
Taber	Wershler (1991a)	In the vicinity of Taber
Vauxhall	Wershler (1991a)	In the vicinity of Vauxhall
Ross Creek	C. Wallis (pers. obs.)	Along Ross Creek, W of Irvine, 23 August 1977
Rainier	Wolford (1966)	Noted as prey of black-crowned night heron
Tilley	Wershler (1981a), Wolford (1966)	Noted as prey of the black-crowned night heron. Wershler (1981a) also reports observations in the vicinity of Tilley
Cassils	Woflford (1966)	Noted as prey of black-crowned night heron
Brooks	Wershler (1991a)	In the vicinity of Brooks
Douglas Creek	C. Wallis (pers. obs.)	At Douglas Creek and Hutton Springs, along the Red Deer River in the mid 1970s
Dinosaur Prov. Park	C. Wallis and C. Wershler (pers. obs.)	Along the N side of Red Deer River in Dinosaur Prov. Park. At least one calling on 12 May 1977 and two calling on 17 June 1977
Lower Red Deer River	Wershler (1991a)	Red Deer River or a tributary creek, NE of Buffalo
Alkali Creek	W. Smith (pers. obs)	Near its junction with the Red Deer River
Alkali Creek	W. Smith (pers. obs.)	N of the previous site, perhaps along Alkali Creek. Records from 1974 and 17 June 1977
Minor Spring	Wershler (1991a)	Downstream from Dune Point on the N side of the Red Deer River
Acadia Valley	C. Wallis (pers. obs.)	Observed in mid-1970s north of Acadia valley; possibly along Empress Creek

APPENDIX 3 continued:

Northern Fescue Grassland Natural Region		
Strathmore	Wershler (1991a)	E of Strathmore
Frank Lake	Bird (1975a)	
High River	Moore and Strickland (1954)	
Hussar	Wershler (1991a)	E of Hussar
Beynon	Wershler (1991a)	Beynon area, probably along Rosebud Creek
Drumheller	Spalding (1980, pg. 131), C. Wallis (pers. obs.)	Drumheller area, probably along Red Deer River. Observed at the Midland Mine in the mid-1970s
Little Fish Lake	W. Smith and C. Wallis (pers. obs.)	Two sites: Handhills Ecological Reserve and Fish Creek. Observed 6 July 1974 and 1 May 1976
Rumsey	C. Wallis (pers. obs.)	Observed in the mid-1970s W of Rumsey in the vicinity of the Red Deer River
Gooseberry Lake Prov. Park	Ebel et al. (1973)	"Occasionally seen around marsh area (W of Lake)"
Central Parkland Natural Region		
Bodo	C. Wallis (pers. obs.)	Observed in the mid-1970s near Bodo, probably along Eyehill Creek
Hayter	C. Wallis (pers. obs.)	Observed in the mid-1970s at a pond N of Hayter
Tail Creek	C. Wallis (pers. obs.)	Observed in the mid-1970s along Tail Creek near its junction with the Red Deer River
Red Deer	K. Wood (pers. comm. to C. Wershler)	Gaetz Lakes
Innisfail	W. Roberts (pers. obs.)	In the vicinity of Innisfail and the Red Deer River
Kneehill Creek	W. Roberts (pers. obs.)	Common along the creek in the mid- to late-1970s
Buffalo Lake	Anderson (1981)	Listed on a species checklist for the area prepared by C. D. Bird
Killarney Lake	C. Wershler & C. Wallis (pers. obs.)	One heard calling upland pond N of Killarney Lake in spring 1982
Black Creek	C. Wallis (pers. obs.)	One heard calling along Black Creek SE of Ribstone on 2 May 1976
Pigeon Lake Prov. Park	Spalding 1980 (pg. 203)	
Foothills - Northern Outliers Natural Region		
Slave Lake	Wershler (1991a)	Near the town of Slave Lake, possibly along the Lesser Slave River
Lesser Slave Lake	Griffiths (1976, in Bradley 1980)	Lesser Slave Lake Prov. Park
Main Foothills Natural Region		
Harold Creek	Wershler (1991a)	In the vicinity of Harold Creek
Clearwater River	Wershler (1991a), W. Roberts (pers. obs.)	Clearwater River near Ricinus and Dovercourt
Crimson Lake Prov. Park	Spalding (1980, pg. 170), C. Wershler (pers. obs.)	One seen in large fen S of Crimson Lake by C. Wershler in July 1973
Boreal Forest - Mixed Wood Natural Region		
Raven River-Caroline	W. Roberts (pers. obs.)	Along the Raven River S and E of Caroline
Glory Hills - Kilini Creek	Spalding 1980 (pg. 206), W. Roberts (pers. obs.)	NW of Red Deer

APPENDIX 3 continued:

Thunder Lake Prov. Park	Friesen and Schaafsma (1973)	
Long Lake Prov. Park	(Spalding 1980, pg. 234), Friesen and Schaafsma (1973)	"Seen in shoreline community"
Steele Lake	Report probably in provincial parks' ecological report from 1973 (C. Wershler pers. comm.)	Cross Lake Prov. Park
Boreal Forest - Hay River Natural Region		
Fitzgerald Settlement	Preble (1908)	Location listed as Smith Landing which is now known as Fitzgerald Settlement.

APPENDIX 4. Recorded sightings of northern leopard frogs in Alberta between 1981 and 1996.

Location	Georeference(a)	Date	Comments	Source (b)
Major Breeding Populations (>100 young-of-the-year observed)				
Bow City	17-17-W4M(*)	1991, 1992, 1996		(Seburn 1992a, 1993), BSOD 1033-1035
Empress Creek	23-1-W4M(*), 23-1-W4M(*), 23-1-W4M(*)	1990-1994		Seburn (1992a, 1993, 1994), Yaremko (1994)
Jenner Pond	21-8-W4M(*)	1990, 1991		Wershler (1991a, 1992a)
Kennedy's Coulee, N of Red Deer River	23-2-W4M	1990, 1991	15 ad., 6 juv.	Wershler (1991a, 1992a)
Little Bow River	12-20-W4M(*)	1990, 1991		Wershler (1992a)
Prince's Spring	21-3-W4M(*)	1990-1995		Wershler (1991b, 1992b), Hofman (1992, 1994a&b, 1995)
Sexton Creek	7-3-W4M(*)	1990-94		Wershler (1991a), Seburn (1992a, 1993, 1994), Yaremko (1994)
Minor Breeding Populations with Direct or Indirect Evidence of Breeding (see text)				
Bashaw	42-20-W4M	17-May-90	males calling in spring	Wershler (1991a)
Blood Indian Creek	23-8-W4M	16-Aug-91	breeding location	Seburn (1992a), BSOD 660, 661
Bow River S of Gleichen	21-23-W4M(*)	28-Aug-90	1 yoy observed.	Wershler (1991a),BSOD 601
Coaldale	9-20-W4M(*)	12-Aug-91	several transforming tadpoles	Seburn (1992a)
Claresholm	11-30-W4M(*)	15-Jul-91	one in creek	Seburn (1992a)
Kennedy Creek	1-6-W4M	1990s		Seburn (1992c), Wershler and Smith (1996)
Little Bow River	13-20-W4M(*)	2-Aug-91	1 ad., 5 yoy	Wershler (1992a)
McKay Creek	36-10-1-W4M	26-Jun-91	breeding site; 3 small ad. and 7 tadpoles seen	Seburn (1992c), C. Wershler (unpubl. data)
Milk River Natural Area	542/521	1990s		Seburn (1992c), Wershler and Smith (1996)
North Saskatchewan River Drainage, Upper Reach (c)	location kept secret at request of landowner	1990s	transplanted frogs doing well in area	W. Roberts (pers. comm.)
Old Channel Lake	14-5-W4M(*), 15-5-W4M	1990, 1991, 1995		Seburn (1992a), Wershler (1991a), A. Didiuk (unpubl. data)
Reesor Lake, Cypress Hills Prov. Park	8-1-W4M	1990 & May1991	males calling in spring, ad. and juv. observed	Seburn (1992a)
Rockyford	26-23-W4M(*)	Jun-91	3+ calling	Seburn (1992a)
St. Mary's River, E of St. Mary Reservoir	5-23-W4M(*)	8-Jul-90	20 juv., 1 tadpole. Record might be suspect (Wershler 1992a)	Seburn (1992a)
Suffield National Wildlife Area	556/524 (NAD 83)(*)	1994-1996	breeding	A. Didiuk (unpubl. data)
Suffield National Wildlife Area	556/524 (NAD 83)(*)	1994-1996	breeding	A. Didiuk (unpubl. data)
Suffield National Wildlife Area	556/524 (NAD 83)(*)	1994-1996	breeding	A. Didiuk (unpubl. data)
Suffield National Wildlife Area	560/542 (NAD 83)(*)	1994-1996	breeding	A. Didiuk (unpubl. data)
Suffield National Wildlife Area	559/531 (NAD 83)(*)	1994-1996	breeding	A. Didiuk (unpubl. data)
Willow Creek	13-29-W4M (*)	Jun-92	4 ad., 75 yoy	D. A. Westworth & Associates (1993)

APPENDIX 4 continued:

Confirmed or Highly Probable Site Records With No Confirmed Evidence of Breeding				
Battle Creek	8-1-W4M	8-Jul-91	7 ad.	Seburn (1992a)
Beaver Creek	10-30-W4M (*)	1990, 1991		Seburn (1992a)
Boquene Lake	121-7-W4M (*)	5-Jun-91	10 observed	Seburn (1992a)
Bow River	12-12-W4M (*)	29-Aug-90	11 ad.	Wershler (1991a)
Bow River at Grand Forks	12-12-W4M (*)	17-Aug-89	2 ad.	Seburn (1992a)
Bow River at Grand Forks	11-13-W4M	11-Aug-91	2 ad.	Seburn (1992a)
Canal Creek	2-5-W4M (*) 2-5-W4M (*)	1990	ad. and juv. observed	Seburn (1992a)
Circle E Project (south and east of Lonesome Lake)	16-17-W4M	1994,1995	several ad. observed, possibly major breeding site	G. Wagner, G. Erickson, S. Brechtel, B. Triechel (1995, pers. obs.), D. Watson (1994, pers. obs.)
Connaught Golf Course	12-5-W4M (*)	1990, 1991	ad. and juv. observed	Seburn (1992a)
Dugout and irrigation canal on N side of the Red Deer River	563/482 (NAD 27)(*)	Aug-93	15 ad. observed	R. Lauzon, unpubl. data
Dugout on N side of the Red Deer River	563/484 (NAD 27)(*)	1993, 1995	ad. observed	R. Lauzon and E. Hofman, unpubl. data
Finnegan Ferry	25-15-W4M (*) 26-16-W4M (*)	1990, 1991	possibly a major breeding location	Wershler (1991a), Seburn (1992a)
Gold Spring Park, along Milk River	2-15-W4M	30-Jun-91	2 ad. observed	Seburn (1992a)
Horse Creek	27-4-W5M, 27-5-W5M (*)	1990, 1996	possible, but unconfirmed breeding	Seburn (1992a), BSOD 460, 572, 1037
J. J. Collett Natural Area, S of Morningside	41-26-W4M	1990	no frogs found in 1991 (Seburn 1992a)	Wershler (1991a)
Kennedy's Coulee, N of the Red Deer River	23-2-W4M	8-Aug-90	15 ad., 6 juv.	Wershler (1991a)
Kneehills Creek near Carbon	29-23-W4M (*)	10-Sep-96	1 ad.	BSOD 1038
Little Bow River	18-29-W4M (*)	20-Sep-96	4 ad. observed	BSOD 463
Lodge Creek	3-1-W4M (*)	29-Aug-90	1 ad.	Wershler (1991a)
Manyberries Creek	5-5-W4M (*)	1990	7 ad.	Seburn (1992a)
Milk River Canyon	1-6-W4M (*)	1-Jul-90	1 observed	Seburn (1992a)
Milk River Canyon	1-6-W4M (*)	1-Jul-90	1 observed	Seburn (1992a)
Milk River Canyon	2-6-W4M (*)	30-Jun-90	1 observed	Seburn (1992a)
Milk River Canyon	2-7-W4M (*)	30-Jun-90	1 observed	Seburn (1992a)
Milk River Canyon	2-7-W4M (*)	30-Jun-90	1 observed	Seburn (1992a)
Milk River Canyon	2-7-W4M (*)	30-Jun-90	1 observed	Seburn (1992a)
Milk River (Pinhorn Ranch)	2-7-W4M	23-Aug-91	200, mostly yoy seen, unconfirmed but highly probable report	Seburn (1992a)
Milk River (town)	2-16-W4M (*)	4-Jul-91	1 ad.	Seburn (1992a)
Pinhorn Grazing Reserve along Milk River	2-7-W4M	1995		L. Powell (pers. obs.)
Police Point Park, Medicine Hat	13-5-W4M (*)	20-Aug-95		BSOD 462
Porcupine Hills	10-30-W4M	10-Aug-91	3 ad.	Seburn (1992a)
Riverbend Campground along Sheep River near Okotoks	20-29-W4M (*)	28-Aug-96	1 ad., 3 juv.	BSOD 1031

APPENDIX 4 continued:

Slack Slough, Red Deer	37-27-W4M (*)	23-Jun-90	2 observed	Seburn (1992a)
S of Lost River Ranch	2-13-W4M (*)	1990	1 observed	Seburn (1992a)
St. Mary's River and Pinepound Creek near Spring Coulee	5-22-W4M	early 1990s	population now believed eradicated	W. Roberts (unpubl. data)
Strathcona Island Park, Medicine Hat	12-5-W4M	1989,1990		Wershler (1991a)
Suffield National Wildlife Area	560/530 (NAD 83)(*)	1-May-96		BSOD 359
Suffield National Wildlife Area	559/536 (NAD 83)(*)	1994		A.Didiuk (unpubl. data)
Suffield National Wildlife Area	556/524 (NAD 83)(*)	1994		A. Didiuk (unpubl. data)
Suffield National Wildlife Area	558-558/532-542 (NAD 83) (*)	1994	along rivers edge between these points	A. Didiuk (unpubl. data)
Suffield National Wildlife Area	558/540 (NAD 83)(*)	1994		A. Didiuk (unpubl. data)
Suffield National Wildlife Area	560/543 (NAD 83)(*)	1994		A. Didiuk (unpubl. data)
Suffield National Wildlife Area	559-560/542-542 (NAD 83)(*)	1994	along rivers edge between these points	A. Didiuk (unpubl. data)
Suffield National Wildlife Area	558/542 (NAD 83)(*)	1994		A. Didiuk (unpubl. data)
Suffield National Wildlife Area	559/542 (NAD 83)(*)	1994		A. Didiuk (unpubl. data)
Suffield National Wildlife Area	558/541 (NAD 83)(*)	1994		A. Didiuk (unpubl. data)
Suffield National Wildlife Area	556/524 (NAD 83)(*)	1995		A. Didiuk (unpubl. data)
Suffield National Wildlife Area	556/524 (NAD 83)(*)	1995		A. Didiuk (unpubl. data)
Suffield National Wildlife Area	556/524 (NAD 83)(*)	1995		A. Didiuk (unpubl. data)
Sunwater Slough	23-8-W4M (*)	1990,1991	2 observed	Seburn (1992a)
Taber Prov. Park	10-16-W4M	1994	8 observations	B. Sundberg, unpubl. data
Tail Creek near its junction with the Red Deer River	39-22-W4M	?	no frogs found in 1991 (Seburn 1992a)	Wershler (1991a)
Weir Bridge, Milk River, 8 miles upstream from Writing-on-Stone Prov. Park	2-13-W4M (*)	23-Jun-90	1 observed	Seburn (1992a)
Willow Creek	13-28-W4M (*)	Jun-92	52 ad. seen during the month	D. A. Westworth & Associates (1993)
Willow Creek	12-28-W4M (*)	Jun-92	19 ad., 1 juv.	D. A. Westworth & Associates (1993)
Writing-on-Stone Prov. Park	1-13-W4M (*)	1990	several records	Seburn (1992a), Wershler (1991a)
Wylie Lake	119-3-W4M	1983		Wallis and Wershler (1983)

(a) Georeferences are given as Township-Range, or as UTM (northing/easting). Accuracy of georeference points indicated with an asterisk (*) has been reduced to protect sites from disturbance. Precise locations may be provided to agencies/individuals with a demonstrated need to know.
(b) (BSOD) refers to record numbers in the Biodiversity/Species Observation Database, maintained by the Fish and Wildlife Division of Alberta Sustainable Resource Development.
(c) Not mapped.

APPENDIX 5a. Northern leopard frog observations during the 2000-2001 inventory in Alberta.

Record*	Date	Site Description	Latitude	Longitude	Adult	Sub-adult	YOY
31	26-Aug-00	Red Creek, west of Coutts	49.0	-112.1	1		
38	2000	Milk River Natural Area	49.0	-110.7	2		
107	28-Jul-00	Kennedy Creek, southeast of Onefore	49.0	-110.7	14	7	350
36 (2 sites)	27-Aug-00	Police Creek; Writing-on-Stone Provincial Park	49.1	-111.6			6
32	4-May-00	Breed Creek, north of Aden	49.1	-111.3	2	1	
47	17-Aug-00	Milk River, south of Pakowki Lake	49.1	-110.9	2	1	1
39	18-Aug-00	Milk River Natural Area	49.1	-110.7	1		1
8	5-Aug-00	Bare Creek, east of Manyberries	49.2	-110.3	1	1	
53	7-Aug-00	Ketchum Creek, east of Pakowki Lake	49.3	-110.8			1
39042	7-Aug-00	Mannyberries area / tributary of Manyberries Creek	49.4	-110.6	8		
8233/54255	28-Aug-00	Michelle Reservoir, northeast of Manyberries	49.5	-110.4	14	4	6
8234	1-Aug-00	Lodge Creek, east of Manyberries	49.5	-110.4	2		153
8214	28-Aug-00	Thelma Creek, south of Elkwater	49.5	-110.3			4
8026	1-Aug-00	Lodge Creek, Eagle Butte area	49.6	-110.4			30
56 (8 sites)	28-Jul-00	Sexton Creek and ponds; Cypress Hills area	49.6	-110.3	32	4	785
51281	27-Jul-01	Graburn, Cypress Hills Provincial Park	49.6	-110.0		31	
57	9-May-00	RANA Site, Cypress Hills Provincial Park	49.7	-110.1	5	14	
51320	7-Aug-00	Oldman River, near Taber	49.8	-112.2	1		
14	24-Jul-00	Bullshead Creek, near Dunmore	49.9	-110.8			44
16	24-Jul-00	Seven Persons Creek, near Medicine Hat	49.9	-110.8	1		6
119	28-Jul-00	Bullshead Reservoir, south of Medicine Hat	49.9	-110.6	2	2	11
11	21-Jul-01	McAlpine Creek, south of Walsh	49.9	-110.0	3		
67 (2 sites)	21-Aug-00	Willow Creek, west of Claresholm	50.0	-113.7	6	5	
63	24-Jul-00	Kin Coulee / Connaught Golf Course, Medicine Hat	50.0	-110.7	1		144
5137	31-Aug-00	South Saskatchewan River, Medicine Hat	50.0	-110.7		1	5
8027	31-Aug-00	South Saskatchewan River, Medicine Hat	50.0	-110.7	2	6	1
64	17-Jul-00	Strathcona Park, Medicine Hat	50.0	-110.6	3		199

* Records 1 to 136 represent ANHIC records; other numbers indicate BSOD records; records in bold represent sites with 10 or more adult and subadult frogs combined.

YOY = Young-of-the-year.

APPENDIX 5a continued:

Record*	Date	Site Description	Latitude	Longitude	Adult	Sub-adult	YOY
71	20-Aug-00	Willow Creek, west of Stavely	50.1	-113.9	2	12	
69 (3 sites)	20-Aug-00	Pine Coulee, west of Stavely	50.1	-113.7	5	36	
131	24-Aug-00	Twelve Mile Coulee, near Rolling Hills	50.1	-111.7		3	4
66	23-Aug-00	Bow River, southeast of Hays	50.1	-111.6	3	3	3
31624	31-Aug-00	South Saskatchewan River, near Medicine Hat	50.1	-110.6		3	1
32403	24-Aug-00	Bow River, southwest of Rolling Hills	50.2	-111.8		7	25
73	14-Sep-00	South Saskatchewan River, CFB Suffield	50.2	-110.7	3	11	5
72	30-Aug-00	Old Channel Lake, CFB Suffield	50.2	-110.6		5	13
109	5-Aug-00	Lonesome Lake, south of Bow City	50.3	-112.3	4	1	2
75	5-Aug-00	Circle E Ranch, near Bow City	50.3	-112.2	1		6
76	6-Aug-00	Minipoka Drain, near Scandia	50.3	-112.2	1		
79 (3 sites)	5-Aug-00	Bow City area	50.4	-112.2	3	9	100s
114	30-Sep-00	Sherwood Forest, CFB Suffield	50.5	-110.6	1		
80	21-Jul-00	Little Bow River, south of High River town site	50.6	-113.9	3		8
39181	18-Sep-01	Stafford Lake, north of Brooks	50.6	-111.9	4		
113	5-Aug-00	Whitco Springs, CFB Suffield	50.6	-110.4		1	
32397	29-Aug-01	Princess, north of	50.7	-111.7	1		
82	4-Aug-00	Bow River, near of Arrowwood	50.8	-113.1	2		100s
83	10-Aug-00	Princes Spring, north of CFB Suffield	50.8	-110.3	7	3	5
86	7-Jun-00	Blood Indian Creek, north of Jenner	50.9	-111.1	4		
85	10-Aug-00	Kennedy Coulee, east of Empress	50.9	-110.2	2		
87	11-Aug-00	Empress Creek, near Empress	51.0	-110.0	1		3
78	01-Aug-01	Finnigan / Spring Creek	51.1	-112.1	6	6	
93	28-Jun-00	Serviceberry Creek, near Rockyford	51.2	-113.2		1	
118	20-Jun-00	Red Deer River, near Atlas Coal Mine	51.3	-112.5	2		
2	19-Aug-00	Wylie Lake, east of Wood Buffalo National Park	59.3	-110.3	1		
5479	20-Aug-00	Leland Lake, east of Fitzgerald	59.9	-111.0	1		

* Records 1 to 136 represent ANHIC records; other numbers indicate BSOD records; records in bold represent sites with 10 or more adult or subadult frogs combined.
YOY = Young-of-the-year.

Hard copies of the data sheets and information collected during the 2000 and 2001 inventory are held at the O.S. Longman Building, Edmonton, Alberta.

APPENDIX 5b. Northern leopard frog sites with no leopard frogs observed during the 2000-2001 inventory in Alberta.

Record*	Date	Site Description	Latitude	Longitude
6	9-Aug-00	Belly River, west of Mountain View	49.0	-113.7
19651	9-Aug-00	Boundary Creek	49.0	-113.5
51310	22-Jul-00	Outpost Lake; Police Outpost Provincial Park	49.0	-113.5
8042	23-Jul-00	Rolph Creek, near Taylorville	49.0	-113.1
8038	23-Jul-00	Lynn Sommerfeldt land	49.0	-113.0
51312	23-Jul-00	Milk River, near Writing-on-Stone Provincial Park	49.0	-113.0
41	26-Aug-00	Red Creek, west of Coutts	49.0	-112.0
40	26-Aug-00	Police Creek; Writing-on-Stone Provincial Park	49.0	-111.7
8170	30-Aug-01	Milk River, 16 miles east and 8 miles south	49.0	-111.7
51292	26-Aug-00	St. Kilda area	49.0	-111.5
1	26-Aug-01	Milk River, west of Wild Horse	49.0	-110.6
27	26-Aug-01	Milk River, west of Wild Horse	49.0	-110.6
8112/8121/51322	29-Aug-00	Wild Horse Area	49.0	-110.2
51296	8-Aug-00	Cottonwood Creek, south of Twin Butte	49.1	-113.9
24	8-Aug-00	Maskinonge Lake, near HWY 6	49.1	-113.8
35	9-Aug-00	Crooked Creek, south of Twin Butte	49.1	-113.8
5	9-Aug-00	Sofa Mountain Beaver Ponds	49.1	-113.7
3	9-Aug-00	Romeril Dam, near Mountain View	49.1	-113.6
8211	24-Jul-00	Milk River Tributary, northeast of Del Bonita	49.1	-112.4
26	24-Jul-00	Milk River town site (lagoon)	49.1	-112.1
28	26-Aug-00	Milk River, southwest of Milk River town site	49.1	-111.9
42	26-Aug-00	Milk River, southwest of Milk River town site	49.1	-111.9
29	15-Aug-00	Milk River, at Pinhorn Grazing Reserve	49.1	-110.9
8201	29-Aug-00	Lost River	49.1	-110.6
43	19-Aug-00	Lost River, west of Onefour	49.1	-110.5
46	2000	Onefour, area near	49.1	-110.5
44	2000	Sage Creek, east of Onefour	49.1	-110.3
31610	2000	Dungaryan Creek, north of Waterton Lakes National Park	49.2	-113.9
51311	9-Aug-00	Mami Creek, near Hillspring	49.2	-113.6
4	22-Jul-00	St. Mary River, near Spring Coulee	49.2	-113.3
48	24-Aug-00	Milk River Ridge, northeast of Del Bonita	49.2	-112.3
45	19-Aug-00	Canal Creek, northwest of Onefour	49.2	-110.6
39037	29-Aug-00	Alberta/Saskatchewan boarder, south of Cypress Hills Provincial Park	49.2	-110.1
22	5-Aug-00	Yarrow Creek, west of Twin Butte	49.3	-113.9
23	5-Aug-00	Drywood Creek, north of Twin Butte	49.3	-113.9
50	25-Jul-00	Middle Coulee, near McNab	49.3	-112.4
48288	2000	Manyberries Creek, southeast of Manyberries	49.3	-110.5
54256	2000	Sage Creek, near Onefour	49.3	-110.5

* Records 1 to 136 represent ANHIC records; other numbers indicate BSOD records.

APPENDIX 5b continued:

Record*	Date	Site Description	Latitude	Longitude
49	19-Aug-00	Middle Creek Reservoir – Lodge Creek, south of Cypress Hills Provincial Park	49.3	-110.0
127	4-Aug-00	Beauvais Lake; Beauvais Lake Provincial Park	49.4	-114.1
34	5-Aug-00	Indian Farm Creek, near Pincher Creek town site	49.4	-113.9
8319	5-Aug-00	Foothills Creek, east of Pincher Creek town site	49.4	-113.9
51	21-Jul-00	Pinepound Creek, near Spring Coulee	49.4	-113.1
54	21-Jul-00	St. Mary River, Blood Indian Reserve	49.4	-113.1
8203/51318	24-Jul-00	Tyrrell Lake (east side)	49.4	-112.2
55	13-Aug-00	Manyberries Creek, near Manyberries	49.4	-110.7
9	5-Aug-00	Lodge Creek, south of Cypress Hills	49.4	-110.3
32380	25-Aug-00	Foremost	49.5	-111.5
32391	29-Aug-01	Peigan Creek, south of	49.5	-110.9
51317	4-Aug-00	Frank Slide area	49.6	-114.4
8035	4-Aug-00	Burmis Bridge Marsh	49.6	-114.3
8220	21-Jul-00	Pothole Creek	49.6	-112.8
15	2000	Peigan Creek, south of Medicine Hat	49.6	-110.8
51294/31626	28-Aug-00	Eagle Butte area	49.6	-110.4
123	25-Aug-00	Spring Creek, Cypress Hills Provincial Park	49.6	-110.3
8190/8200	28-Aug-00	Thelma Creek	49.6	-110.3
31629	29-Aug-01	Elkwater, south of	49.6	-110.3
51289	29-Jul-01	Elkwater, south of – Cypress Hills Provincial Park	49.6	-110.3
8315	10-Aug-00	Oldman River Campground	49.7	-113.5
8013/8033	20-Jul-00	Lethbridge, in or near	49.7	-112.9
9522	25-Aug-00	Bow Island, south of	49.7	-111.4
8181	25-Aug-00	Seven Person's Creek (Red Rock Coulee)	49.7	-111.0
13	10-Aug-00	Seven Persons, east of Bow Island	49.7	-110.6
10	2000	Elkwater Lake, Cypress Hills Provincial Park	49.7	-110.3
8167	2000	SW corner of Cypress Hill Provincial Park	49.7	-110.3
31628	29-Aug-01	Spruce Coulee (Cypress Hills Provincial Park)	49.7	-110.2
31625	29-Aug-01	Graburn Monument / Gap, Cypress Hills Provincial Park	49.7	-110.1
59	3-Aug-00	Beaver Creek, north of Pincher Creek town site	49.8	-113.9
7479	3-Aug-00	Moyninhan Ranch, west of Claresholm	49.8	-113.9
32382-83	10-Aug-00	Willow Creek, west of Stavely	49.8	-113.5
8036	10-Aug-00	Willow Creek, Oldman River confluence	49.8	-113.4
58	21-Aug-00	Oldman River, near Diamond City	49.8	-112.7
7	7-Aug-00	Oldman River, near Taber Municipal Park	49.8	-112.2
37	25-Aug-00	Yellow Lake, southwest of Bow Island	49.8	-111.7
51319/8052	22-Aug-00	Picture Butte reservoir	49.9	-112.8
51291	30-Aug-00	Cavan Lake Area	49.9	-110.4
12	29-Aug-00	Dunmore – Elkwater Lake turnoff	49.9	-110.3
60	2000	Mackay Creek, south of Walsh	49.9	-110.0

* Records 1 to 136 represent ANHIC records; other numbers indicate BSOD records.

APPENDIX 5b continued:

Record*	Date	Site Description	Latitude	Longitude
62	20-Aug-00	Trout Creek, west of Claresholm	50.0	-113.8
65	7-Aug-00	Little Bow, south of Travers Reservoir	50.0	-112.6
51321	22-Aug-00	Vauxhall reservoir	50.0	-112.2
8225	6-Aug-01	Irvine, west of	50.0	-110.6
8327	2000	Rose Creek, west of Irvine	50.0	-110.3
31620	19-Aug-00	Unnamed creek, at HWY 527	50.1	-114.0
31621	19-Aug-00	Willow Creek, west of Stavely	50.1	-114.0
68	7-Aug-00	Little Bow, south of Travers	50.1	-112.7
8037	23-Aug-00	Vauxhall, at DU project	50.1	-112.1
8041	24-Aug-00	Vauxhall Canal	50.1	-112.1
8114	24-Aug-00	Hays irrigation canal	50.1	-111.8
8213	23-Aug-00	12 Mile Coulee Creek	50.1	-111.7
1540	24-Jul-00	Echodale Park, west of Medicine Hat	50.1	-110.9
8050	30-Aug-00	Redcliff Coulee	50.1	-110.8
70	31-Aug-00	Mitchell Creek, northeast of Medicine Hat	50.1	-110.6
128	12-Jul-00	Chain Lakes Reservoir	50.2	-114.2
32402	20-Aug-00	Oxley (Oxley Creek)	50.2	-113.9
32400	24-Aug-00	EID Canal southeast of Scandia	50.2	-112.0
8326	12-Jul-00	Mosquito Creek	50.3	-114.2
51299	6-Aug-00	Scandia, near Bow City	50.3	-112.1
110	5-Aug-00	Lonesome Lake, north of	50.4	-112.3
77	23-Jun-00	Lake Newell, south of	50.4	-111.9
51323	5-Jun-00	Brooks, south of	50.5	-111.9
17	5-Jun-00	Johnson/Jamieson Lake, north of Brooks	50.6	-111.9
32396	5-Jun-00	Onetree Reservoir	50.6	-111.8
33	21-Jul-00	Okotoks Campground	50.7	-113.9
108	2001	San Francisco Lake, near Brooks	50.7	-112.1
116	6-Jun-00	Millicent	50.7	-111.8
32390	6-Jun-00	Princess	50.7	-111.5
7131	26-Sep-01	Millarville, west of	50.8	-114.3
32394	4-Aug-00	Bow River, southwest of Bassano	50.8	-112.6
8199/19655	17-Jun-00	Dinosaur Provincial Park	50.8	-111.5
81	9-Aug-00	Jenner Springs, near Jenner	50.8	-111.0
94	25-Jul-00	Priddis Creek, near Priddis	50.9	-114.6
1573	25-Jul-00	Wildrose Country Estates (Bragg Creek)	50.9	-114.6
20	25-Jul-00	Priddis Creek Golf Course	50.9	-114.4
111	25-Jul-00	Fish Creek / Whiskey Creek, near Priddis	50.9	-114.4
21	25-Jul-00	Priddis / Fish Creek	50.9	-114.3
96	24-Jul-00	Fish Creek Park, Calgary	50.9	-114.1
1561	5-Jul-00	Stobart	50.9	-113.2
8031	5-Oct-01	Gleichen, in or near	50.9	-113.1
1550	2001	Brooks Pheasant Hatchery (area)	50.9	-112.0

* Records 1 to 136 represent ANHIC records; other numbers indicate BSOD records.

APPENDIX 5b continued:

Record*	Date	Site Description	Latitude	Longitude
18965	2001	Brooks, north of	50.9	-112.0
117	6-Jun-00	Wardlow	50.9	-111.6
84	7-Jun-00	Howie	50.9	-111.3
5484	16-Oct-01	Red Deer River, north of	50.9	-111.2
51309	10-Aug-00	Red Deer River, northwest of Bindloss	50.9	-110.4
9524	17-Sep-01	Calgary, west of	51.0	-114.2
97	13-Jul-00	Glenmore Park, Calgary	51.0	-114.1
100	18-Jul-00	Westmill Shopping Center - Calgary	51.0	-114.1
98	14-Jul-00	Beaver Dam Flats Park, Calgary	51.0	-114.0
99	10-Jul-00	Inglewood Bird Sanctuary - Calgary	51.0	-114.0
25	2-Jun-00	Eagle Lake	51.0	-113.3
124	16-Oct-01	Red Deer River / Douglas Creek	51.0	-112.0
122	6-Jun-00	Hutton	51.0	-111.8
101	3-Aug-00	Westchete Gravel Pits -Calgary (Bowmont Flats)	51.1	-114.2
9481	26-Jul-00	Bearspaw	51.1	-114.2
95	14-Jul-00	Edworthy Park, Calgary	51.1	-114.1
1571	3-Aug-00	Nosehill Park, Calgary	51.1	-114.1
8116/8124	20-Jul-00	Nose Creek (Calgary)	51.1	-114.1
8110/8056/11092/ 8030/20382-84	11-Jul-00	Calgary	51.1	-114.1
8125	20-Jul-00	Airport Road (Calgary)	51.1	-114.0
51324	2-Jun-00	Strathmore, area	51.1	-113.4
1575	2000	Alkali Creek, west of Bindloss	51.1	-110.7
9562	26-Jul-00	Beaupre Creek	51.2	-114.6
104	26-Jul-00	Mitford, west of Calgary	51.2	-114.5
103	19-Jul-00	Bighill Creek (Cochrane)	51.2	-114.4
102	14-Jul-00	Beddington Creek, Calgary	51.2	-114.1
9519	25-May-00	Rockyford	51.2	-113.1
88	28-Jun-00	Severn Reservoir / Creek	51.2	-113.0
9455/19656	11-Aug-00	Acadia Valley	51.2	-110.3
1037	19-Jul-00	Bottrel – Horse Creek	51.3	-114.6
1572/39031	19-Jul-00	Bottrel	51.3	-114.5
9513/11091	26-May-00	Rosebud	51.3	-112.9
8021	6-Sep-01	Locality of Beyon, in or near	51.3	-112.8
1568	10-Sep-01	Crossfield	51.4	-114.0
5181	6-Sep-01	Willow Creek area	51.4	-112.6
89	20-Jun-00	Little Fish Lake	51.4	-112.2
51335	19-Jul-00	Harold Creek (Waiparous)	51.5	-114.9
1038	27-Jun-00	Carbon	51.5	-113.1
32385	24-May-00	Sharples	51.5	-113.0
51327	24-May-00	Hesketh, northeast of	51.5	-112.9

* Records 1 to 136 represent ANHIC records; other numbers indicate BSOD records.

APPENDIX 5b continued:

Record*	Date	Site Description	Latitude	Longitude
51314	24-May-00	Kneehill Creek, near Drumheller	51.5	-112.8
8192	31-Aug-01	Sundre, south of - Fallen Timber Creek	51.6	-114.6
8005	6-Sep-01	Morrin	51.7	-112.8
8018-20	6-Sep-01	Drumheller area	51.7	-112.7
136	14-Jul-00	Dowling Lake, southwest corner	51.7	-112.1
135	4-Jul-00	Dowling Lake, southeast corner	51.7	-112.0
19657	29-May-00	Trochu, at Red Deer River	51.8	-113.0
5921	3-Aug-00	Big Valley area	51.9	-112.7
8034	20-Aug-01	Crammond, in or near	52.0	-114.7
8193	20-Aug-01	Caroline, 6 mile S of	52.0	-114.6
105	5-Aug-00	Unnamed creek, near Ricinus	52.1	-115.0
120	15-Aug-00	Beaver Creek, near Caroline	52.1	-114.7
51333	20-Aug-01	Raven River, near Caroline	52.1	-114.7
51332	31-Aug-01	Clearwater River, near Dovercourt	52.2	-114.9
90	2-Aug-00	Slacks Slough, south of Red Deer	52.2	-113.8
5226	3-Aug-00	Stettler, area near	52.2	-112.7
51315	14-Jul-01	Eychill Creek, near Bodo	52.2	-110.1
51326	2000	Gaetz Lakes, Red Deer	52.3	-113.8
125	16-Aug-00	Tail Creek, near Nevis	52.3	-113.1
1577	14-Aug-00	Chambers Creek Camp Ground	52.4	-115.3
9546	17-Oct-00	Chambers Lake / Buster Creek	52.4	-115.2
19	4-Aug-00	Crimson Lake Provincial Park	52.4	-115.0
18	15-Aug-00	Rocky Mountain House area	52.4	-114.9
51316	14-Jul-01	Hayter, north of	52.4	-110.1
5487	5-Aug-00	West Lobstick Creek, northeast of Rocky Mountain House	52.5	-114.8
9497/9499	2-Aug-00	Aspen Beach Provincial Park	52.5	-114.0
9458	3-Aug-00	Rochon Sands Provincial Park	52.5	-112.9
9462	15-Aug-00	Buffalo Lake	52.5	-112.9
19658	15-Jul-01	Black Creek, southeast of Ribstone	52.5	-110.4
9496	4-Aug-00	Grace Creek, northwest of Rocky Mountain House	52.6	-115.3
51337	2-Aug-00	J.J. Collett Natural Area, near Morningside	52.6	-113.6
608	18-Sep-01	Buffalo Lake, north of	52.6	-112.9
91	17-Aug-00	Killarney Lake	52.6	-110.1
9516	14-Jul-01	Dillberry Lake	52.6	-110.0
92	16-Aug-00	Hardisty	52.7	-111.3
52782	30-Jul-01	Battle River, near Wainwright	52.9	-111.0
132	7-Sep-00	Cawes Lake	53.4	-113.4
9445/9448/9452	2000	Vermilion Provincial Park	53.4	-111.0
134	2000	Edmonton, U of A farm	53.5	-113.5
133	2000	Walter Lake / Blackfoot Recreation area, near Uncas	53.5	-112.9

* Records 1 to 136 represent ANHIC records; other numbers indicate BSOD records.

APPENDIX 5b continued:

Record*	Date	Site Description	Latitude	Longitude
106	8-27 Aug 01	Heatherdown, near Stony Plain	53.6	-114.1
51334	8-24 Aug 01	Kilini Creek; Glory Hills	53.6	-114.1
8032	18-Sep-00	Edmonton	53.6	-113.5
1581	2001	Edmonton	53.6	-113.3
1580	2001	Ardrossan, west of	53.6	-113.0
1576	8-27 Aug 01	Chip Lake area	53.7	-115.3
130	8-27 Aug 01	Thunder Lake Provincial Park	54.1	-114.7
51328	23-Aug-01	Long Lake Provincial Park	54.4	-112.8
8184	16-Aug-01	Little Smoky, south of	54.6	-117.1
8366	24-Aug-01	Cross Lake Provincial Park	54.7	-113.8
959	9-Sep-00	Muskoseepi Reservoir	55.1	-118.9
8183	28-Sep-00	Sturgeon Creek	55.2	-117.3
51330	16-Aug-01	Lesser Slave Lake Provincial Park	55.3	-114.7
9498	23-Aug-01	Highlevel, east of	58.5	-116.9
39041	19-Aug-00	Bocquene Lake and wetlands, east of Wood Buffalo National Park	59.5	-111.0

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